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EJECTION TOWER EVALUATION OF THE RATE-DEPENDANT FOAM CUSHIONS FOR THE NACES SEAT

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13. ABSTRACT (*Maximum 200 words*)

Fifety two tests were conducted at the NAWC Warminster Ejection Tower Site. Seven cushion configurations were used in the test program to measure their effect on ejection safety. It was clearly seen that the Confor foam cushion enables the manikin to be more effectively coupled to the seat than the current NACES cushion. Based on these test results, it was found that the NACES cushion foam could be replaced with the Confor Foam to improve seated comfort without degrading ejection safety. This report describes the test articles, test procedures, data collection and data analysis used for the evaluation.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Test Purposes

The ability of polyurethane foam to improve comfort over foam rubber in aircraft seats has been documented many times. A recent Navy message (ref a) requested the use of this foam in all Navy and Marine ejection seats. A U.S Air Force study (ref b) also showed that a sheepskin seat cover provides additional comfort. The optimum ejection seat comfort cushion is likely to be two inches of polyurethane foam with a half-inch thick sheep skin top cover. At this time, it is planned to replace the NACES seat pan foam with one inch thick C-47 Confor Foam. This ejection seat cushion change will improve comfort, leading to improved aviator performance. With the incorporation of thicker foams, improved lumbar support, and sheepskin covers, additional comfort will be experienced.

The ejection seat cushion also affects ejection safety. Cushion compression under catapult (ejection gun) acceleration can contribute to back injuries. An Air Force test program, (ref c), compared ejection safety of two-inch thickness of polyurethane foam with operational cushions. This program exposed human subjects to 10 G drop tests, and compared some physiological responses between existing cushions and polyurethane foam cushions. The results clearly showed that polyurethane foam cushions were safer or equal in safety to the existing cushions. In addition to the Air Force tests, NAWC considers it necessary to test manikins with 14 G ejection gun accelerations, using the proposed seat cushions prior to Navy fleet introduction.

The primary objective of this test program was to verify that either the one-inch-thick C-45 Confor Foam or the one-inch-thick C-47 Confor Foam NACES seat cushion produces manikin force/acceleration ejection responses equal to or less than the current NACES cushion. Prior to testing these cushions, tests were conducted with no seat cushion and with a thick foam rubber cushion known to be injurious during ejections. These results verified that our test methods could measure cushion response, and determined where the less stressful responses are for each data channel. The two one-inch-thick Confor Foam cushions and the NACES cushion were then tested . Also tested were a two-inch-thick C-47 Confor Foam cushion and a one-inch-thick C-47 Confor Foam Cushion with a sheepskin cover. The manikin response data was used to;

a. verify different cushion materials could be detected
b. determine if ejection response is different between the one inch thick C-45 and the one inch thick C-47.
c. determine if ejection response is different between the one inch thick C-47 and the two inch thick C-47.
d. determine if the sheepskin cover changes ejection response
e. determine which cushion configurations are as safe as or safer than the NACES cushion
f. validate the Bioman computer model.

1.2 Cushion Test Articles

Seven cushion configurations were used in the test program. Table I summarizes the test articles. The MIL-R-5001A COMP.2 TY2 CL.FIRM GR.A material was used as the "bad" cushion. The tables and graphs abbreviate this material as MIL-R-5001A. The three Confor Foam cushions are described by their thickness and type on the graphs and charts (ex. 1 in. C-45). The one inch C-47 cushion with the sheepskin cover is abbreviated as Sheepskin.

Table I

Cushion Test Articles

Foam Insert	Thickness	Cover
"No" Cushion	0	None
MIL-R-5001A COMP.2 TY2 CL.FIRM GR.A	1 7/8 In.	None
Current NACES (PN 327E670-5)	1 In.	PN 325E670-1
Confor Foam PN CF-45100 (C-45)	1 In.	PN 325E670-1
Confor Foam PN CF-47100 (C-47)	1 In.	PN 325E670-1
Confor Foam PN CF-47200 (C-47)	2 In.	PN 325E670-1
Confor Foam PN CF-47100 (C-47)	1 In.	Sheepskin Top

1.3 Test requirements

Prior to permitting the Confor Foam cushions for fleet use, it was required to prove these cushions are as safe as or less stressful than the current NACES cushion. The data listed in Table II are measures of cushion performance. To evaluate these cushions, all other test conditions were kept constant. Differences in measurements between cushions are than solely due to the cushion configuration. Since the pretest conditions were not kept perfectly constant in the test set-up, tests were repeated to establish a range of responses for the cushion, with differences in other pretest conditions being equally distributed. Time traces of the data in Table II were recorded during each test. From these traces, the peak values, the time of the peak value, and the area under the curve to catapult separation were extracted as measures of stress for use in comparing responses between cushion configurations.

Table II

Performance Measurements

Catapult Pressure
Catapult Vertical Acceleration (Gz)
Seat Vertical Acceleration (Gz)
Pelvis Vertical Acceleration (G_z)
Thorax Vertical Acceleration (G_z)
Head Vertical Acceleration (G_z)
Pelvis Horizontal Acceleration (G_x)
Thorax Horizontal Acceleration (G_x)
Head Horizontal Acceleration (G_x)
Lumbar Compression Force (F_z)
Lumbar Shear Force (F_x)
Lumbar Bending Moment (M_y)

1.4 Summary

Appreciable differences in test results were evident when comparing the "no" cushion data to the "bad" cushion data. The data peaks were always lower with the "no" cushion data than with the "bad" cushion data. All four Confor Foam cushions produced lower data peaks than the NACES cushion data. The Confor Foam data also showed that the vertical forces were transmitted to the manikin earlier and with a slower onset than with the NACES cushion. Also, the peaks of the vertical data were more level with the Confor Foam cushions. Based on the performance criteria shown in paragraph 1.3, this data shows that the cushions with Confor Foam are as safe as the NACES cushion. The data also show that the two inch thick C-47 Confor Foam produced results similar to the one inch cushion results, and both one inch cushions produced results almost identical to each other. The sheepskin cover degraded the C-47 cushion performance, but still provided results as safe as with the NACES cushion. Based on these test results, it was found that the NACES cushion foam could be replaced with the Confor Foam to improve seated comfort without degrading ejection safety.

1.5 Reference Documents

(a) Message 130439Z DEC 90
(b) F-15E Letter Report, TEVJ (Ed George, AUTOVON 527-2246), Department of the Air Force, Headquarters, 6510th Test Wing (AFSC), Edwards Air Force Base, CA 93523
(c) Bernard F. Hearon, M.D., and James W. Brinkley, "Effect of Seat Cushions on Human Response to Gz Impact," Aviation, Space, and Environmental Medicine, Feb. 1986
(d) Draft NAVAIRDEVCEN "Ejection Tower Facility Operations Manual (ETFOM)," dated June 1990.

2.0 TEST EQUIPMENT IDENTIFICATION.

2.1 Electronic Instrumentation

The transducers used to measure the performance of the cushions are described in Table III. The signals from these transducers were passed to a Honeywell TMS 3000 through 200 feet of cable. A 200Hz filter was used to smooth the data. A Vu-Point data analysis program was used to reduce the data.

2.2 Optical Instrumentation

Two high-speed video cameras provided coverage of the ejection stroke from ositions in front of the seat and from the right hand side of the seat. The video recording system is described in Table IV.

The high-speed video was reviewed to confirm the initial position of the manikin and adequacy of the restraint performance. This coverage was only be used to observe either very large differences in position or a complete failure of the restraint system.

TABLE III

ELECTRONIC DATA TRANSDUCERS

Fifth Percentile Manikin Tests

CHAN.	NOMENCLATURE	MOD. NO	SER. NO	MANF.	SENSITIVITY	ACC.	RANGE
1.	Catapult pressure	PT135-5M	24407	C.E.C.	0.06234 mV		0-5000 psi
2.	Catapult Gz	4-202	30212	C.E.C.	0.090556 mV		± 50 G
3.	Seat Gz	4-202	17067	C.E.C.	0.09226 mV		± 50 G
4.	Head Gz	4-202	17065	C.E.C.	0.098844 mV		± 50 G
5.	Head Gx	4-202	15692	C.E.C.	0.170156 mV		± 25 G
6.	Thorax Gz	4-202	26830	C.E.C.	0.089805 mV		± 50 G
7.	Thorax Gx	4-202	5177	C.E.C.	0.188673 mV		± 25 G
8.	Pelvis Gz	2262A	WA02	Endevco	0.467228 mV		± 100 G
9.	Pelvis Gx	2262A	RR63	Endevco	0.524211 mV		± 100 G
10.	Lumbar Force Fz	1001	#28	R.A. Denton	0.0228 mV	± 5 %	0-5000 lbs.
11.	Lumbar Moment My	1001	#28	R.A. Denton	0.0843 mV	± 5 %	0-3000 /in.-lbs.
12.	Lumbar Force Fx	1001	#28	R.A. Denton	0.0302 mV	± 5 %	0-3000 lbs.

Ninety-Fifth Percentile Manikin Tests

CHAN.	NOMENCLATURE	MOD. NO	SER. NO	MANF.	SENSITIVITY	ACC.	RANGE
1.	Catapult pressure	PT135-5M	24407	C.E.C.	0.06234 mV		0-5000 psi
2.	Catapult Gz	4-202	30212	C.E.C.	0.089951 mV		± 50 G
3.	Seat Gz	4-202	17067	C.E.C.	0.096095 mV		± 50 G
4.	Head Gz	4-202	30207	C.E.C.	0.092113 mV		± 50 G
5.	Head Gx	4-202	15692	C.E.C.	0.170156 mV		± 25 G
6.	Thorax Gz	4-202	26830	C.E.C.	0.089805 mV		± 50 G
7.	Thorax Gx	4-202	5177	C.E.C.	0.188673 mV		± 25 G
8.	Pelvis Gz	2262A	WA02	Endevco	0.467228 mV		± 100 G
9.	Pelvis Gx	2262A	RR63	Endevco	0.524211 mV		± 100 G
10.	Lumbar Force Fz	1001	#31	R.A. Denton	0.0229 mV	± 5 %	0-5000 lbs.
11.	Lumbar Moment My	1001	#31	R.A. Denton	0.0878 mV	± 5 %	0-3000 /in.-lbs.
12.	Lumbar Force Fx	1001	#31	R.A. Denton	0.0307 mV	± 5 %	0-3000 lbs.

TABLE IV

VIDEO RECORDING EQUIPMENT

	NOMENCLATURE	MODEL NO	SERIAL NO	MANUFACTURER
1.	Video Camera	1000 High-Gain Imager	6935	KODAK EASTMAN CORP
2.	Video Camera	1000 High-Gain Imager	7035	KODAK EASTMAN CORP
3.	Video Tape Recorder	1000 High Speed Motion Analyzer	3765	KODAK EASTMAN CORP

3.0 TEST FACILITY AND SET-UP

3.1 Ejection Tower

All tests described herein were conducted at the NAWC Warminster Ejection Tower Site. The ejection seat tower is a 150-ft. structure inclined and supported at an angle of 20 degrees from the vertical. It is capable of accepting any ejection seat and has been used for a variety of studies related to egress systems. Being man-rated, it is an important tool in determining the physiological acceptability of escape system acceleration forces using manikins or human volunteer subjects. The Ejection Tower Facility Operations Manual (ref d) describes the procedures for ejection tower operations.

The 40-inch steel NAMC catapult was used to provide the acceleration input. All tests used a 30 inch solid plug and 82 to 83 grams of propellant from the MK-18 MOD 0 cartridge. Catapult pressure acts against a pushing area in the catapult tube to accelerate the seat up the rails. A constant cartridge propellant weight was used which burns in the same initial volume to produce the same pressure input in all tests.

3.2 Ejection Seat

All tests used a NACES wide-bucket ejection seat especially modified for ejection tower testing. To minimize the total ejected weight (TEW), on the ejection tower, the seat was stripped of unnecessary components. The ejection seat maintained requisite strength and contained the actual seated geometry, seat cushioning and restraint systems, including Powered Inertia Reel Device (PIRD), manual override, locks, releases, and parachute riser webbings. All tests with the fifth percentile manikin were conducted with a full-up seat-height adjustment. All test with the 95th percentile manikin were with the seat-height adjustment full down.

3.3 Manikins

A 5th percentile, Hybrid III-type manikin (serial number 106), was dressed only in an MA-2 torso harness to eliminate the effects of flight gear on the manikin's response, and allow more accurate position measurement. The 5th percentile test manikin weighed 165 pounds. A 95th percentile, Hybrid III-type manikin (serial number 147), was also dressed only in an MA-2 torso harness and weighed 223 pounds. Both manikins represent flesh with a foam rubber cover which acts as a cushion during ejections.

The manikins were disassembled and thoroughly inspected prior to testing to assure that they were properly assembled with undamaged components and performed according to their specifications. No disassembly inspections or adjustments were made during the test program to avoid the possibility of altering the manikins response characteristics. The manikins joint motion was checked and found acceptable before each test.

4.0 TEST PROCEDURES

4.1 Test Conditions

Table V contains a listing of the test conditions. To compare ejection response between cushions, tests were conducted with different cushions, with the cushion being the only variable between tests. This procedure allowed comparison responses between cushion tests and assumed that any difference in responses was due to the cushion. Since it could not adequately be assured that other major influencing factors, such as catapult performance, manikin position, and restraint were exactly identical, testing was repeated under identical conditions to establish a range of responses. It was assumed that the effects of these other influences were equally distributed in these data ranges. Prior to each exposure, the following steps were used to control these other influencing factors:

- Verify temperature is within range (62 - 82 degrees F).
- Hang manikin by head hook.
- Place cushion in seat.
- Place manikin on cushion, bend torso forward.
- Push on legs so buttocks are tight against seat back.
- Attach lap belts and shoulder restraints.
- Wait 10 minutes before tightening the restraint.
- Lock and retract the inertia reel straps and apply pretensioning
- Tighten lap belt.
- Adjust shoulder harness straps as tight as possible.
- Measure manikin head position.
- Load catapult according to proper checklist.
- Position feet.
- Record temperature.
- Fire the seat in accordance with the proper checklist procedure.

4.2 Data Reduction

The electronic data in Table II was recorded for all tests. Data was recorded on the Honeywell TMS 3000. This data was than manipulated using a Vu-point data analysis program. After reading the data into the Vu-point program, the times were shifted to match 750 PSI on the catapult curve to 50 msec. Matching 750 PSI to 50 ms, assures all tests have an equal input energy slope at a common time and initiation occurred around 0 ms.. All curves from the test were shifted by this same amount of time. All ordinate data were then set to start at zero by setting the average value for 50 msec preceding time zero (t_0) to zero. An eleven point smoothing technique (10 ms moving average) was than performed on each curve. The data was than saved on a Vu-point file for later data analysis and plotting.

Peaks in the data, the time peaks occurred, and the area of the data between t_0(initiation) and catapult separation were determined and are presented in the Data Tables of Appendix A. The Peak value was the highest value recorded between T_o and catapult separation. The time of peak value was the corresponding time the peak value occurred. The area of each data channel was obtained by using Vu-point to integrate each curve between T_o and catapult separation.

TABLE V
TEST CONDITIONS

TEST NO.	TEST DATE	TOWER NO.	TEMP °F	CUSHION TYPE	(TEST) (NO)	MANIKIN SIZE
1	5/4/92	7047	61	None	(1)	5th
2	5/4/92	7048	62	MIL-R-5001A, Type 2, Firm	(1)	5th
3	5/6/92	7049	61	None	(2)	5th
4	5/7/92	7050	55	MIL-R-5001A, Type 2, Firm	(2)	5th
5	5/7/92	7051	55	MIL-R-5001A, Type 2, Firm	(3)	5th
6	5/7/92	7052	55	None	(3)	5th
7	5/7/92	7053	60	None	(4)	5th
8	5/7/92	7054	60	None	(5)	5th
9	5/11/92	7055	66	None	(6)	5th
10	5/11/92	7056	70	MIL-R-5001A, Type 2, Firm	(4)	5th
11 *	5/11/92	7077	73	MIL-R-5001A, Type 2, Firm	(5)	5th
12	5/11/92	7058	73	MIL-R-5001A, Type 2, Firm	(6)	5th
13 *	5/11/92	7059	74	None	(7)	5th
14	5/14/92	7060	78	MIL-R-5001A, Type 2, Firm	(7)	5th
15	5/21/92	7061	71	C-47, 1-inch	(1)	5th
16	5/21/92	7062	78	C-47 w/Sheepskin Cover	(1)	5th
17	5/21/92	7063	83	NACES Standard Cushion	(1)	5th
18	5/21/92	7064	84	C-47 w/Sheepskin Cover	(2)	5th
19	5/22/92	7065	71	C-47, 2-inch	(1)	5th
20	5/22/92	7066	78	C-47 w/Sheepskin Cover	(3)	5th
21	5/22/92	7067	82	NACES Standard Cushion	(2)	5th
22	5/22/92	7068	85	NACES Standard Cushion	(3)	5th
23	5/29/92	7069	67	C-47 w/Sheepskin Cover	(4)	5th
24	5/29/92	7070	68	C-45, 1-inch	(1)	5th
25	5/29/92	7071	71	C-45, 1-inch	(2)	5th
26	5/29/92	7072	72	C-47, 1-inch	(2)	5th
27 *	5/29/92	7073	73	NACES Standard Cushion	(4)	5th
28 *	6/1/92	7074	66	C-47, 1-inch	(3)	5th
29	6/1/92	7075	67	C-47, 2-inch	(2)	5th
30	6/1/92	7076	71	C-47, 2-inch	(3)	5th
31	6/1/92	7077	69	C-47 w/Sheepskin Cover	(5)	5th
32 *	6/1/92	7078	71	C-45, 1-inch	(3)	5th
33	6/2/92	7079	63	C-47, 1-inch	(4)	5th
34	6/2/92	7080	66	NACES Standard Cushion	(5)	5th
35	6/2/92	7081	70	C-45, 1-inch	(4)	5th
36	6/2/92	7082	70	C-47, 2-inch	(4)	5th
37	6/2/92	7083	73	C-47, 2-inch	(5)	5th
38 *	6/2/92	7084	73	C-47 w/Sheepskin Cover	(6)	5th
39	6/3/92	7085	70	NACES Standard Cushion	(6)	5th
40	6/3/92	7086	73	NACES Standard Cushion	(7)	5th
41	6/3/92	7087	75	C-47, 1-inch	(5)	5th
42 *	6/3/92	7088	76	C-47, 2-inch	(6)	5th
43	6/3/92	7089	82	C-47, 1-inch	(6)	5th
44	6/3/92	7090	82	C-45, 1-inch	(5)	5th
45 *	6/12/92	7091	77	NACES Standard Cushion	(1)	95th
46	6/12/92	7092	78	C-47, 1-inch	(1)	95th
47	6/12/92	7093	83	C-47, 1-inch	(2)	95th
48	6/12/92	7094	85	NACES Standard Cushion	(2)	95th
49 *	6/15/92	7095	75	C-47, 1-inch	(3)	95th
50	6/15/92	7096	76	NACES Standard Cushion	(3)	95th
51	6/15/92	7097	78	NACES Standard Cushion	(4)	95th
52	6/15/91	7098	80	C-47, 1-inch	(4)	95th

* INDICATES A REPRESENTATIVE TEST

Temperature and catapult pressure are major influencing factors in the manikins response to ejection acceleration. Since tests occurred with ranges of temperatures and catapult pressures, a representative test for each cushion was chosen with a temperature near 72°F and a peak catapult pressure of approximately 1675 PSI. These tests are underlined in the data Tables in Appendix A to allow a single test comparison between cushions. Comparison plots were made of these tests and are presented in Appendix B. Each fifth percentile manikin data channel has two plots with four curves on each plot. The first plot compares the "no" cushion, MIL-R-5001A foam, current NACES cushion and the one inch C-47 foam. The second plot compares the four Confor Foam cushions. The ninety fifth percentile manikin data plots contain two curves on each plot comparing the standard NACES cushion response to the 1 in C-47 cushion response.

5.0 DATA ANALYSIS

5.1 Initial Conditions

Table A-1 presents some initial conditions for the test program. Temperature is known to effect the cushion, manikin and catapult performance. Since the ejection tower is an outdoor facility, allowances were made for a range of ambient test temperatures. The range selected was 72°F ± 10°. To expedite the testing some tests were conducted outside this temperature range.

The first fourteen tests were conducted to verify that the testing methodology could measure a difference in manikin response due to different cushion material. As long as both conditions were tested in the same temperature range, it was acceptable to conduct these tests below 62° F. Five tests were conducted above 82° F. due to a rise in afternoon temperatures rose. The temperature range, of the 38 tests with the NACES and Confor Foam cushions, was 63°F - 85° F. Twenty two of these tests were conducted with the temperature between 67°F - 77° F.

Table A-1 also presents measurements of head distances below a plate. The manikin was positioned in the seat for 10 minutes to allow for cushion depression. The restraint was then tightened and the head position was measured. A plate was placed on the head box that extended over the manikins head. A square was dropped through a centered groove, to a head target. This showed the manikin was centered on the seat and also measured the head distance below the plate. This data shows little difference between the sitting height with the one inch Confor Foam cushions and the current NACES cushion as shown in Table A-1.

5.2 Electronic Data Analysis

The acceptance criteria, as stated in paragraph 1.3, was to demonstrate that the manikin response with the confor foam cushion was the same as or less stressful than with the NACES cushion. Data peaks, time of peaks, and curve area are being used as initial measurements of stress. These measures are

presented in the Data Tables of appendix A, with the average and standard deviation calculated for each cushion.

The most significant channels for measuring cushion performance recorded during this test program were:

Catapult Pressure,
Catapult Vertical Acceleration,
Pelvis Vertical Acceleration, and
Thorax Vertical Acceleration.

Plots of these data channels are discussed below to describe the cushions performance. The horizontal data channels are less useful for evaluating cushion response because other influencing factors, such as the restraint system, may have a larger influence on the response than the cushion alone in this direction. No harmful responses were discovered in any data channel, so only the most significant channels are discussed in the analysis.

5.2.1 Input Force

Catapult pressure acts against a pushing area in the catapult tube to produce the force to accelerate the seat up the rails. As the seat moves, it pushes the cushion which pushes the manikin. A constant input force between tests is necessary to compare manikin responses. All tests relied on a constant cartridge propellant weight, which burns in the same initial volume, to produce the same pressure input.

As seen in Table A-2 the peak pressures ranged from 1538 to 1780 PSI. In addition to internal volume and propellant weight, other factors such as temperature and the manikin influence the peak pressure. Table A-2 shows that all of the peak pressures representing all of the 7 cushion configurations fall within a standard deviation of the NACES average peak pressure. It is believed that the other influencing factors are distributed evenly among the tests.

Figures B-1 to B-3 show time plots of the pressure input for the representative tests. Since there is very little difference in these curves, it can be assumed that differences in other representative curves are not due to different pressure inputs.

5.2.2 Cushion Performance

The cushion effects can be seen in the catapult vertical acceleration curves of figure B-4. As a cushion compresses, only part of the total ejected weight is being pushed by the catapult. When the cushion is fully compressed a delay is seen in the acceleration onset because of the additional load being pushed. Figure B-4 shows the "bad" cushion acceleration reaching a level at 50 ms. At this time, the seat and manikin are fully coupled and the curve shows a pronounced dip due to the full load acting on the catapult. This event takes approximately 15 ms for the catapult to react to this total propelled mass. The catapult then begins to accelerate the seat/manikin combination at a higher rate of onset which results in a higher peak load or overshoot when compared to the other cushions with less compression.

The Confor Foam cushions are not supposed to compress when exposed to impact loads. Figure B-5 shows all Confor Foam curves are nearly identical

with no noticeable delay in the acceleration onset. These cushions have even decreased the cushion effect of the manikins rubber skin by supporting the manikins weight over a large area.

Table A-3 shows only one of the Confor Foam cushion tests had a peak catapult acceleration above 16.6G (the NACES average, plus one standard deviation). This high acceleration is attributed to the high pressure input and not to the cushion. Manikin data from this test showed that even with a higher catapult acceleration, the cushion produced lower manikin accelerations, without overshoot, than the current NACES cushion.

The cushion compression is also evident in the pelvis acceleration curves of figures B-7 to B-9. As a cushion compresses, the pelvis acceleration is delayed. Figure B-7 shows the Confor Foam cushion reaches 2 G about 5ms earlier than the no cushion and NACES cushion tests, and about 10 ms earlier than the bad cushion test. During this delay, the seat builds a velocity, so the manikin must now obtain a higher acceleration to match the seat velocity. The manikin then begins to accelerate at a higher rate of onset which results in a higher peak load or overshoot when compared to the other cushions with less compression.

This overshoot effect occurs in all vertical manikin data channels, and is very evident in the thorax vertical acceleration curves of figure B-10. The no cushion test has a peak of 15 G at 65ms, the NACES cushion test has a 17 G peak at 75 ms, and the bad cushion test has a 19 G peak at 80 ms. Following these peaks, all the accelerations dropped then peaked again (overshoot). The Confor Foam curve has a lower onset, without overshoot, and reaches a 16 G peak at 125 ms. Figure B-11 shows all Confor Foam cushion tests have the same acceleration vs time shape.

6.0 CONCLUSIONS

It was clearly seen that the Confor foam cushion enables the manikin to be more effectively coupled to the seat than the current NACES cushion. Better coupling was first evidenced in the catapult acceleration curves. This was seen by a smaller decrease of the acceleration onset halfway through the rise portion of the pulse. In addition, all vertical channels measured in the manikin showed evidence of better coupling due to earlier loading, slower rate of onset of the forces, and finally, by lower peak accelerations. The horizontal data channels are less useful for evaluating cushion response because of other influencing factors, such as the restraint system, which may have a larger influence on the response than the cushion alone in this direction.

The Confor foam cushions will provide a margin of improved safety over the current NACES cushion. All Confor Foam cushions remained firm during the impact and transferred the seat acceleration to the manikin quicker than the NACES cushion. Thus all Confor Foam cushion configurations produced less dynamic overshoot than the NACES cushion.

Ejection performance of the cushion is independant on the seat design, therefore the results can be extrapolated to include any ejection seat. The results also show that new Crew Stations can improve seated comfort, with

thicker Confor Foam cushions and sheepskin covers, without degrading ejection safety.

7.0 RECOMMENDATIONS

Based on the above study, it is safe to incorporate, as appropriate, either one inch or two inch thick Confor Foam Cushions as a replacement for existing ejection seat cushions for NACES, SJU-5, GRU-7 and ESCAPAC type seats.

APPENDIX A

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

INITIAL CONDITIONS

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	TEMPERATURE (DEG F)								
NONE	61	61	55	60	60	66	74	62	6
MIL-R-5001A	62	55	55	70	73	73	78	67	9
NACES	83	82	85	73	66	70	73	76	7
1 IN. C-45	68	71	71	70	82	-	-	72	6
1 IN. C-47	71	72	66	63	75	82	-	72	7
2 IN. C-47	71	67	71	70	73	76	-	71	3
SHEEPSKIN	78	84	78	67	69	73	-	75	6
	HEAD DISTANCE BELOW PLANE (IN)								
NONE									
MIL-R-5001A									
NACES	3.6	3.3	3.4	3.4	3.3	3.3	3.3	3.4	.1
1 IN. C-45	3.1	3.2	3.3	3.3	3.3	-	-	3.2	.1
1 IN. C-47	3.6	3.1	3.2	3.3	3.3	3.4	-	3.3	.2
2 IN. C-47	2.4	2.4	2.5	2.6	2.7	2.6	-	2.5	.1
SHEEPSKIN	3.3	3.3	3.1	3.1	3.0	3.1	-	3.2	.1

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

CATAPULT PRESSURE

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (PSI)								
NONE	1590	1538	1591	1596	1663	1659	1678	1616	51
MIL-R-5001A	1674	1601	1625	1780	1698	1643	1661	1669	58
NACES	1632	1694	1698	1689	1706	1597	1645	1666	41
1 IN. C-45	1658	1739	1692	1664	1765	–	–	1704	47
1 IN. C-47	1632	1627	1692	1715	1728	1671	–	1678	42
2 IN. C-47	1627	1670	1631	1653	1611	1670	–	1644	24
SHEEPSKIN	1679	1698	1674	1583	1701	1665	–	1667	43
	TIMES OF PEAK VALUE (msec)								
NONE	116	116	115	114	117	115	114	115	1
MIL-R-5001A	115	116	117	115	117	116	116	116	1
NACES	116	117	115	116	115	119	119	117	2
1 IN. C-45	116	115	117	115	117	–	–	116	1
1 IN. C-47	116	116	115	116	117	116	–	116	1
2 IN. C-47	117	118	117	116	118	119	–	118	1
SHEEPSKIN	116	116	116	117	117	118	–	117	1
	AREA (PSI-SEC)								
NONE	179	176	178	178	182	181	182	179	2
MIL-R-5001A	181	179	180	187	183	181	181	182	3
NACES	180	183	183	183	185	181	182	182	2
1 IN. C-45	182	185	184	185	187	–	–	185	2
1 IN. C-47	180	180	182	187	185	182	–	183	3
2 IN. C-47	180	183	181	184	180	183	–	182	2
SHEEPSKIN	182	183	183	178	184	182	–	182	2

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

CATAPULT ACCELERATION

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (G)								
NONE	14.7	14.4	14.9	14.9	15.5	15.7	16.0	15.2	.6
MIL-R-5001A	16.3	15.6	15.7	18.1	17.4	16.6	16.4	16.6	.9
NACES	15.9	16.6	16.4	16.5	16.1	15.0	15.5	16.0	.6
1 IN. C-45	15.7	16.5	15.8	15.4	17.0	-	-	16.1	.7
1 IN. C-47	15.2	15.0	15.8	15.8	16.4	15.9	-	15.7	.5
2 IN. C-47	14.9	15.3	15.0	15.0	14.8	15.5	-	15.1	.3
SHEEPSKIN	15.9	16.4	16.0	14.6	16.1	15.6	-	15.8	.6
	TIMES OF PEAK VALUE (msec)								
NONE	106	105	110	103	104	99	101	104	4
MIL-R-5001A	109	104	107	109	107	105	109	107	2
NACES	103	103	102	103	102	103	103	103	0
1 IN. C-45	108	107	107	107	107	-	-	107	0
1 IN. C-47	108	113	107	106	111	107	-	109	3
2 IN. C-47	113	121	120	110	115	121	-	117	5
SHEEPSKIN	107	108	104	108	107	109	-	107	2
	SEPERATION VELOCITY (FT/SEC)								
NONE	51.8	51.2	52.2	52.5	53.5	53.1	53.5	52.5	.9
MIL-R-5001A	52.8	52.2	51.8	54.1	53.5	52.5	53.1	52.9	.8
NACES	52.5	53.8	53.8	53.5	54.5	51.8	52.8	53.2	.9
1 IN. C-45	52.8	54.1	53.5	52.8	55.1	-	-	53.7	1.0
1 IN. C-47	52.5	52.5	53.5	53.1	54.1	53.1	-	53.1	.6
2 IN. C-47	52.5	53.1	53.5	52.5	52.2	53.5	-	52.7	.5
SHEEPSKIN	53.5	53.8	53.5	51.2	53.5	53.1	-	53.1	1.0

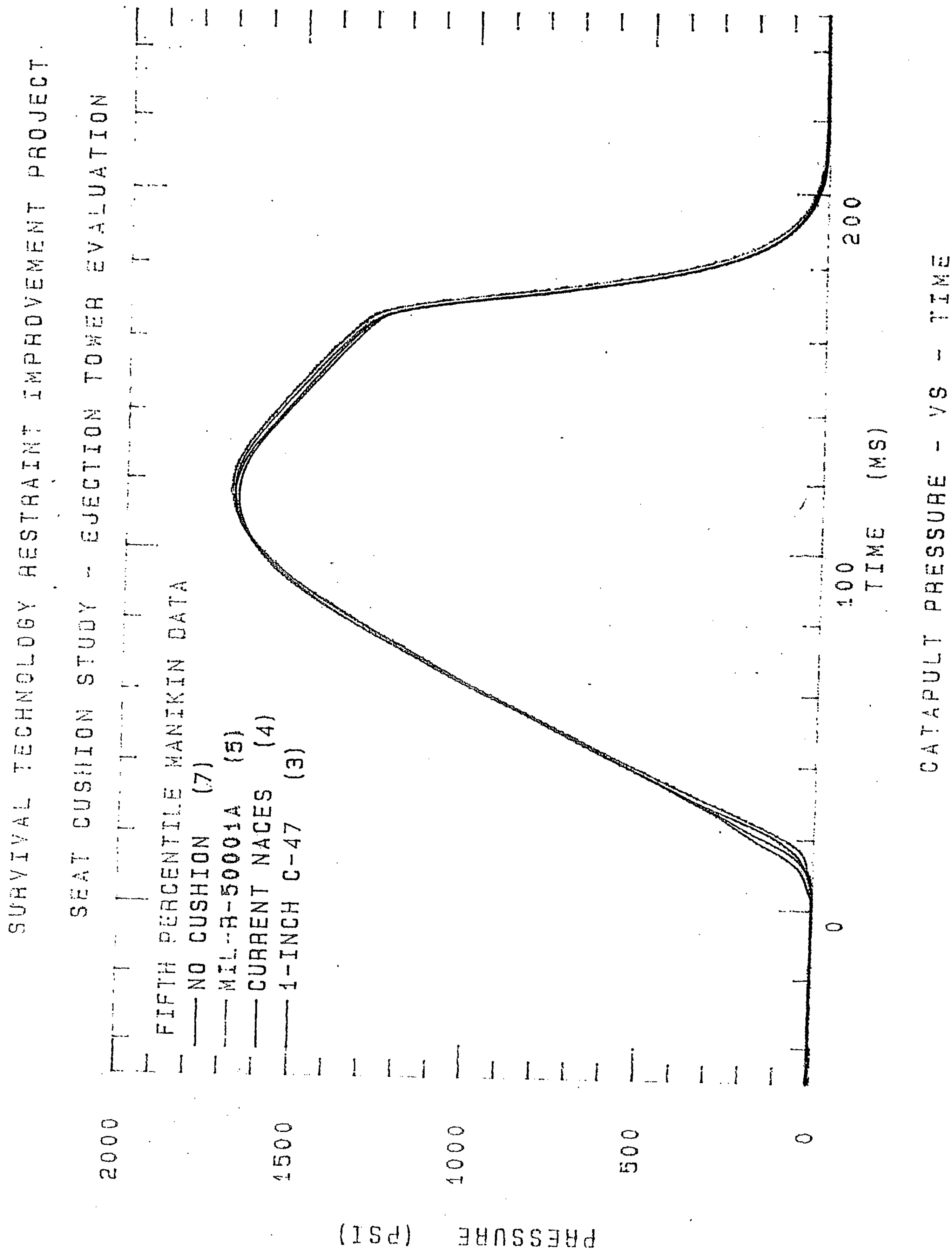
STRIP CUSHION EVALUATION
EJECTION TOWER DATA

NINETY-FIFTH PERCENTILE MANIKIN TESTS

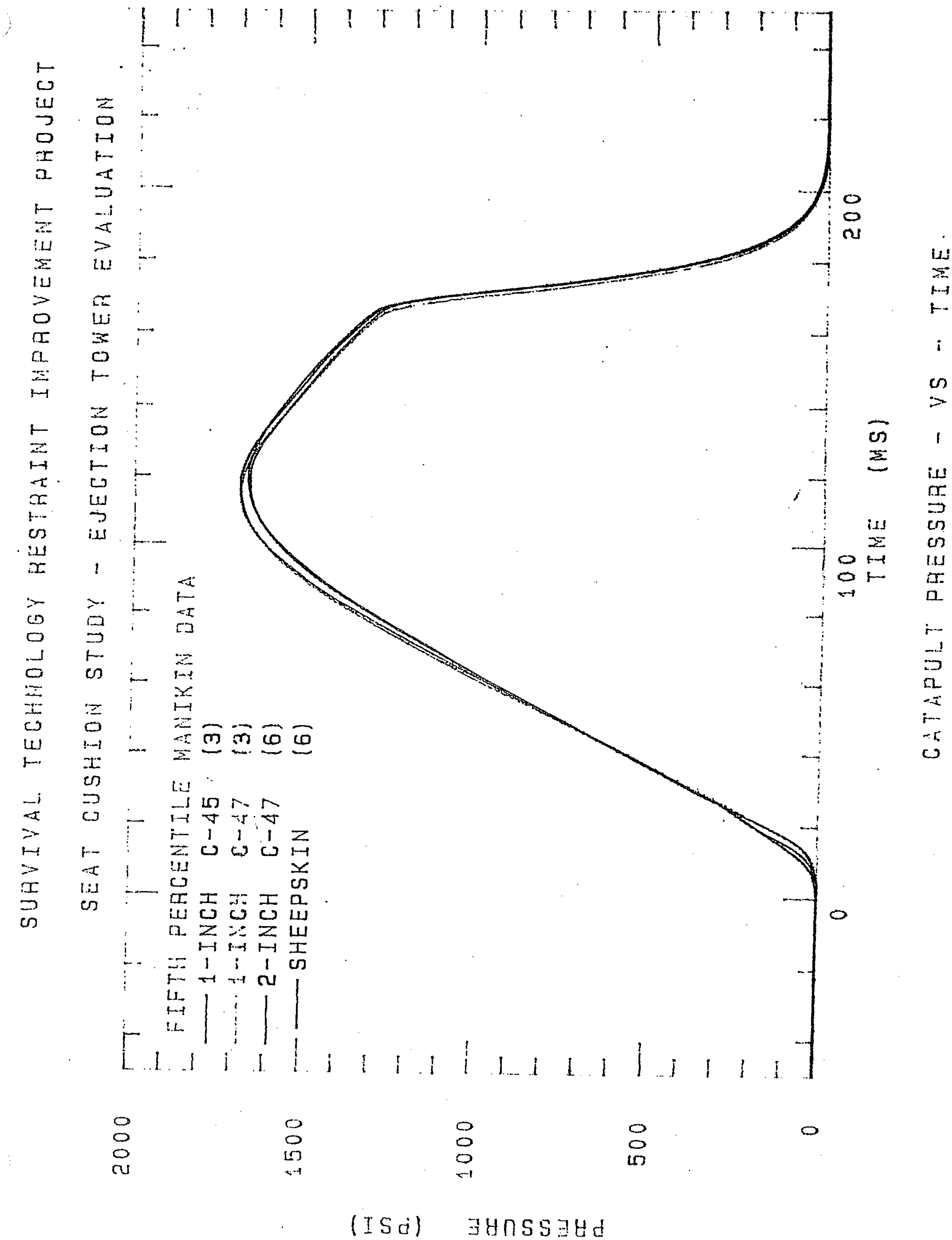
PEAK ELECTRONIC INSTRUMENTATION VALUES

NACES TESTS					1 IN C-47 TESTS			
1	2	3	4		1	2	3	4
1699	1850	1798	1831	CAT PRE (PSI)	1801	1726	1712	1769
14.9	16.0	15.4	15.9	CAT ACC (Gz)	15.4	14.4	14.4	14.7
14.4	16.2	15.4	16.1	SEAT ACC (Gz)	15.3	14.8	14.6	15.2
14.6	15.3	14.7	15.3	PELVIS ACC (Gz)	15.0	14.5	14.3	14.6
16.3	16.0	16.0	16.1	THORAX ACC (Gz)	15.6	15.1	14.9	14.9
13.4	14.9	14.0	14.7	HEAD ACC (Gz)	12.8	12.9	12.3	12.3
0.3	1.5	0.3	1.2	PELVIS ACC (Gx)	1.1	2.2	0.1	0.4
0.2	0.6	0.1	0.6	THORAX ACC (Gx)	0.5	1.1	0.2	0.2
13.6	17.4	15.4	16.0	HEAD ACC (Gx)	16.5	15.0	13.6	15.5
1562	1659	1546	1631	LUMBAR COMP (LB)	1572	1558	1463	1499
256	48	252	96	LUMBAR SHEAR (LB)	248	161	265	210
1790	1550	1571	1436	BEND MOM (IN-LB)	1629	1120	1750	1422

APPENDIX B

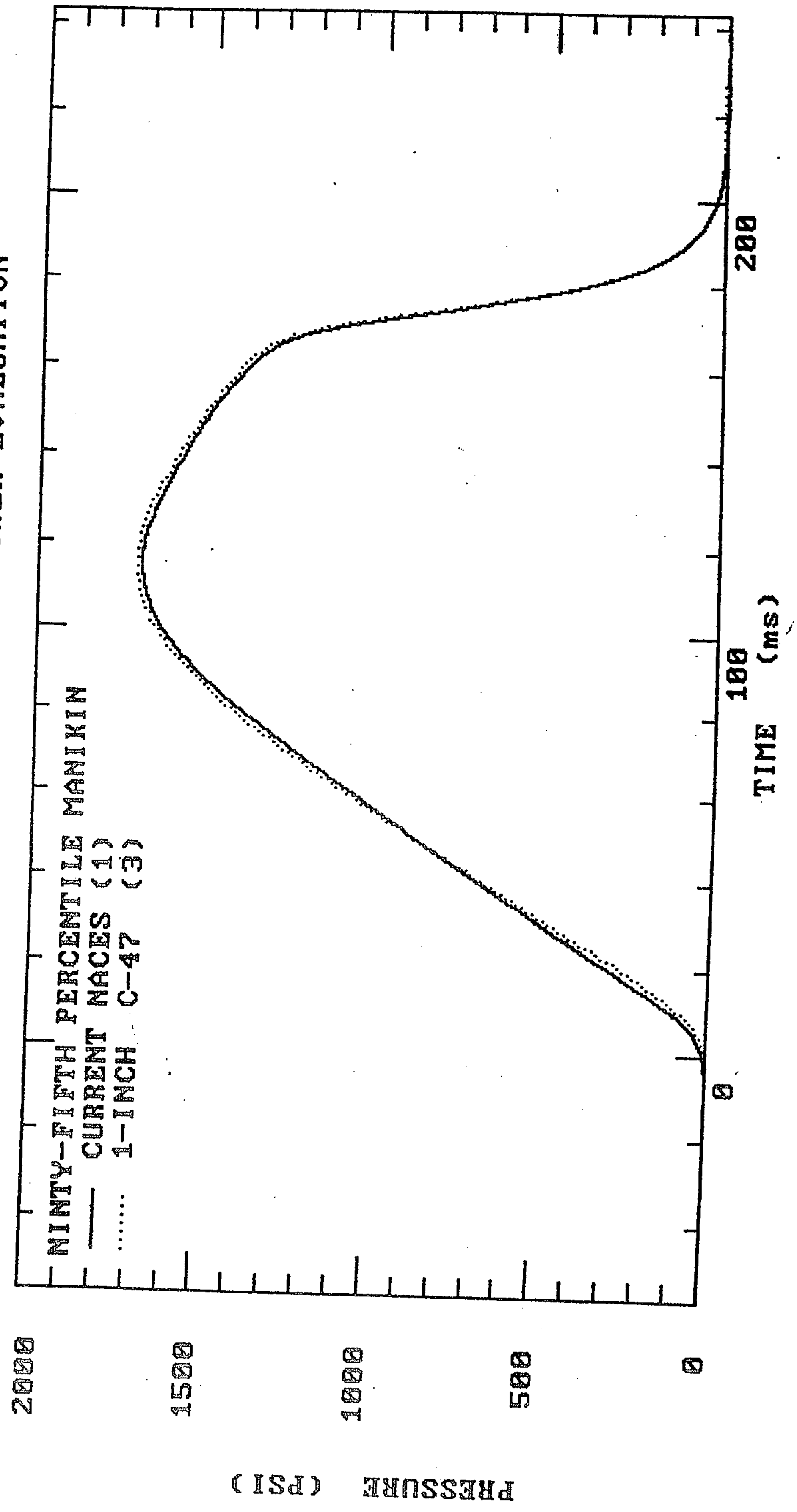


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-50001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
2000
1500
1000
500
0
PRESSURE (PSI)
0
100
200
TIME (MS)
CATAPULT PRESSURE - VS - TIME

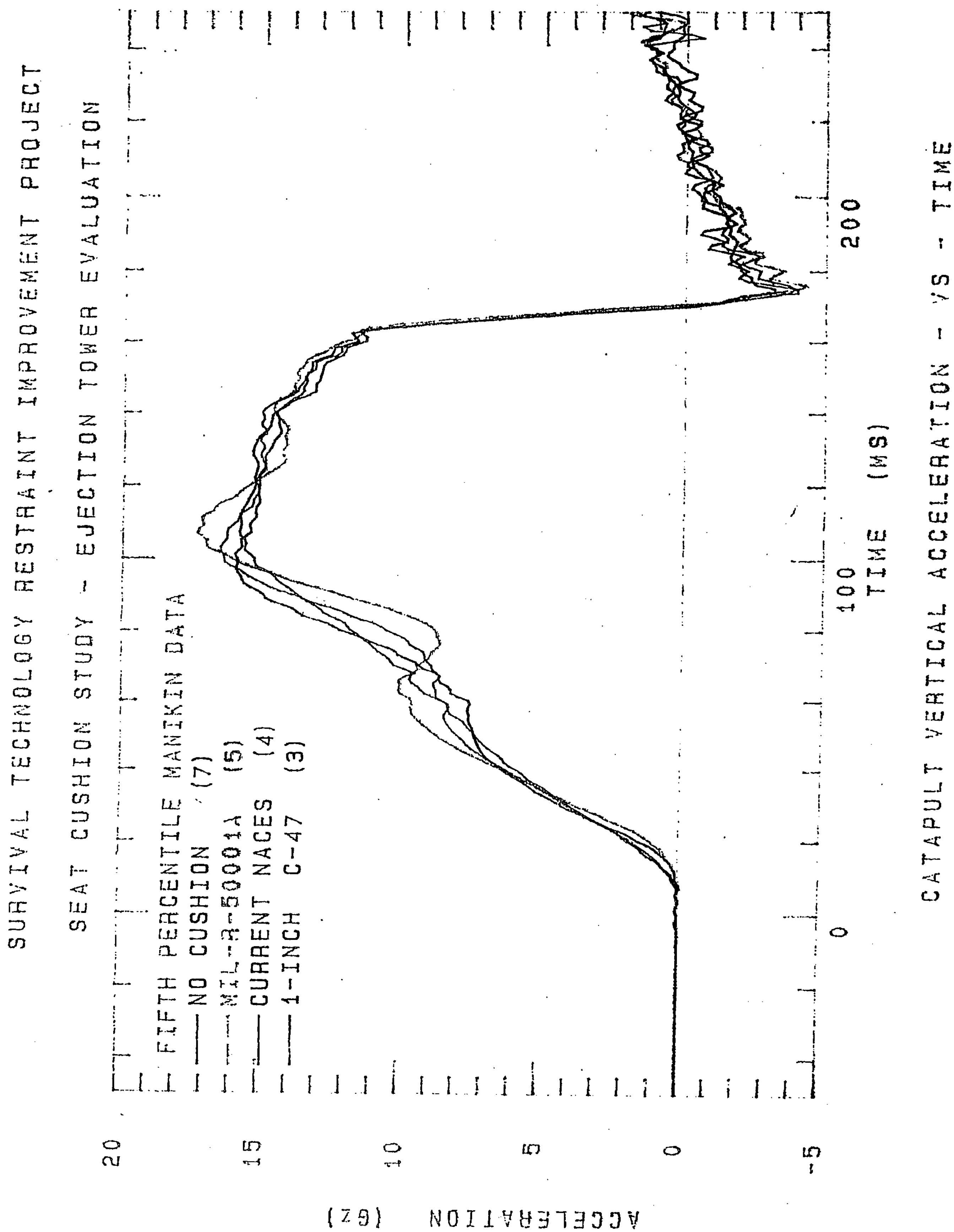

SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
PRESSURE (PSI)
2000
1500
1000
500
0
0
100
200
TIME (MS)
CATAPULT PRESSURE - VS - TIME

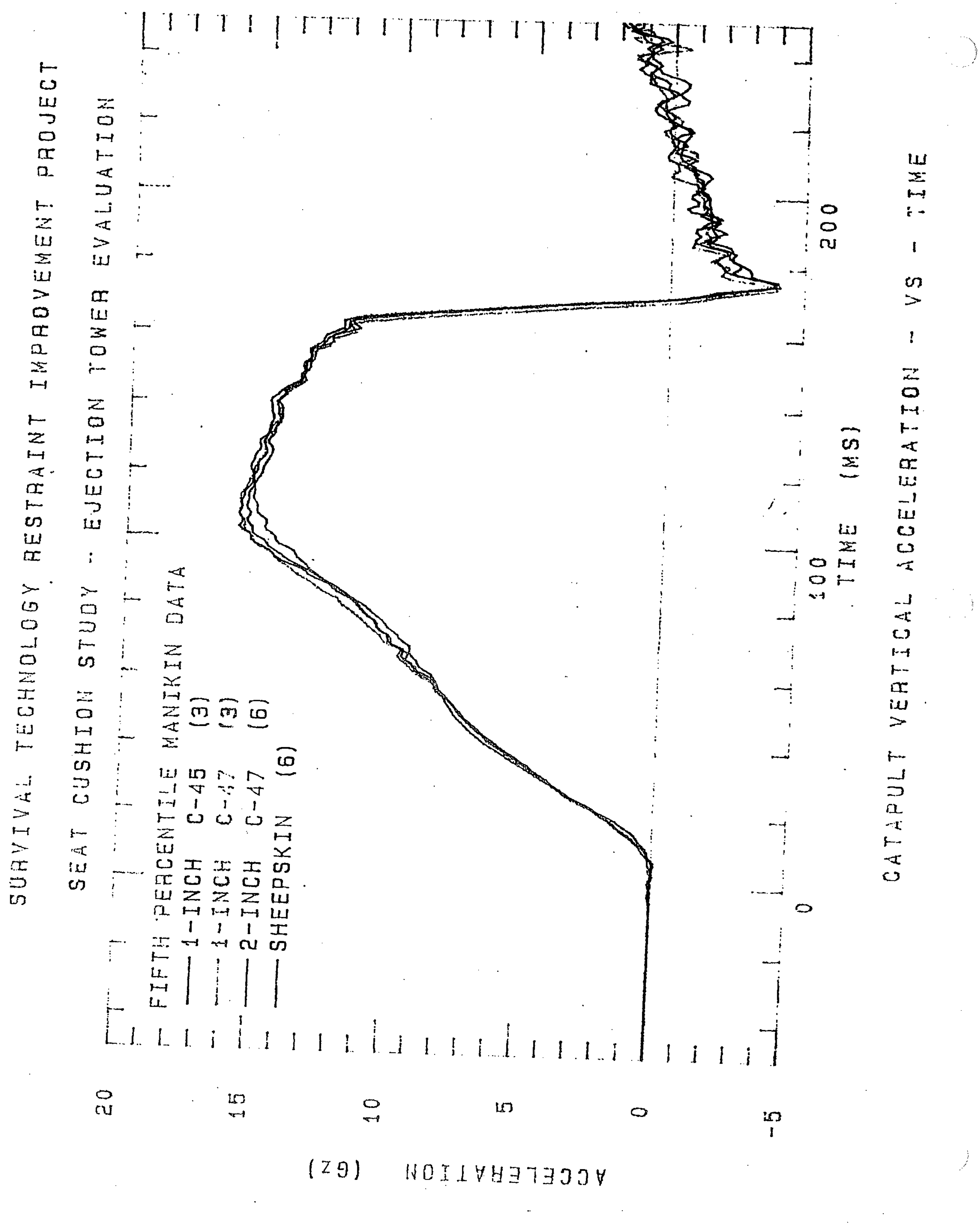
SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT

SEAT CUSHION STUDY - EJECTION TOWER EVALUATION



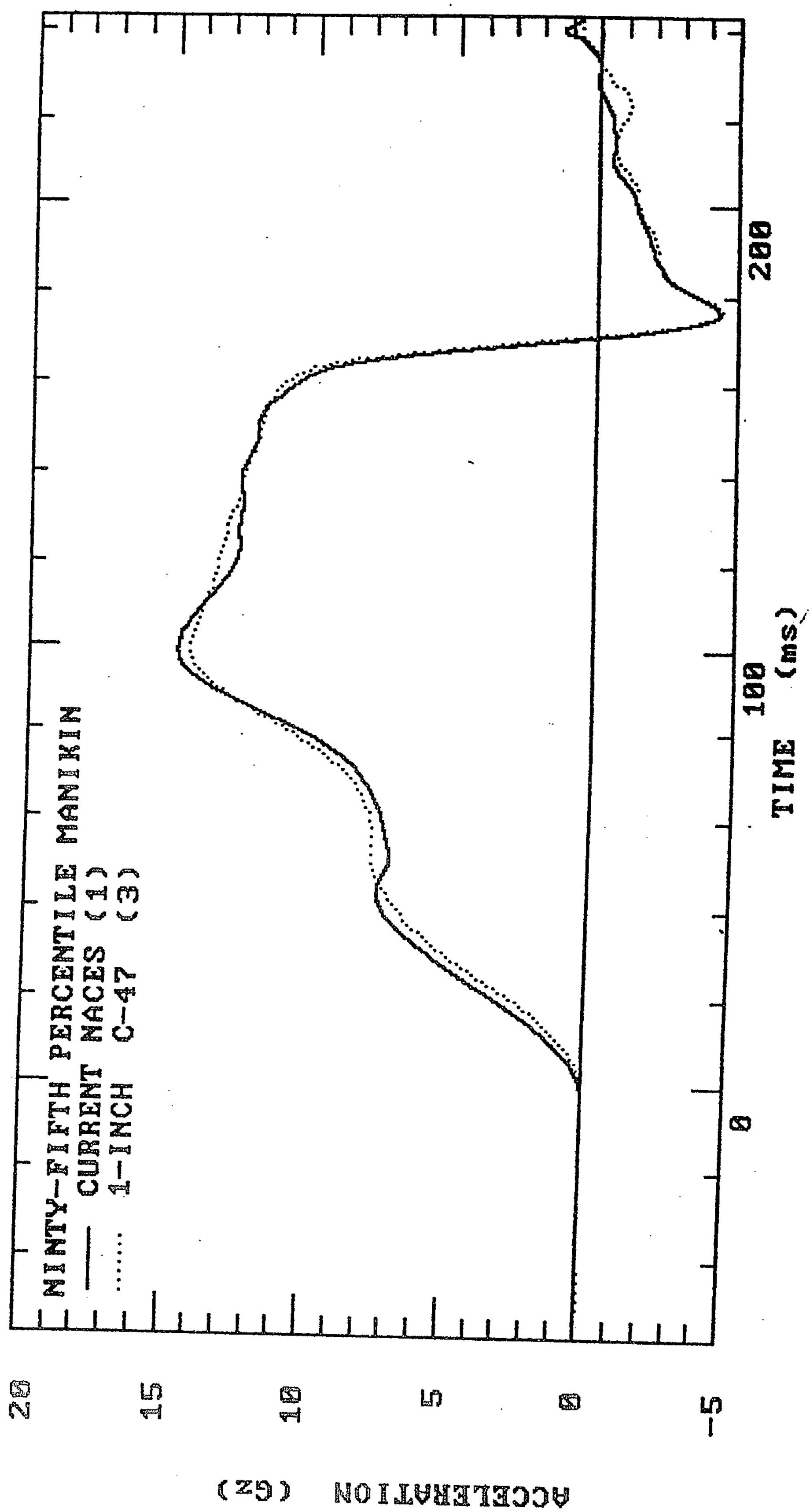
CATAPULT PRESSURE - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-5001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
20
15
10
5
0
-5
ACCELERATION (Gz)
0
100
200
TIME (MS)
CATAPULT VERTICAL ACCELERATION - VS - TIME

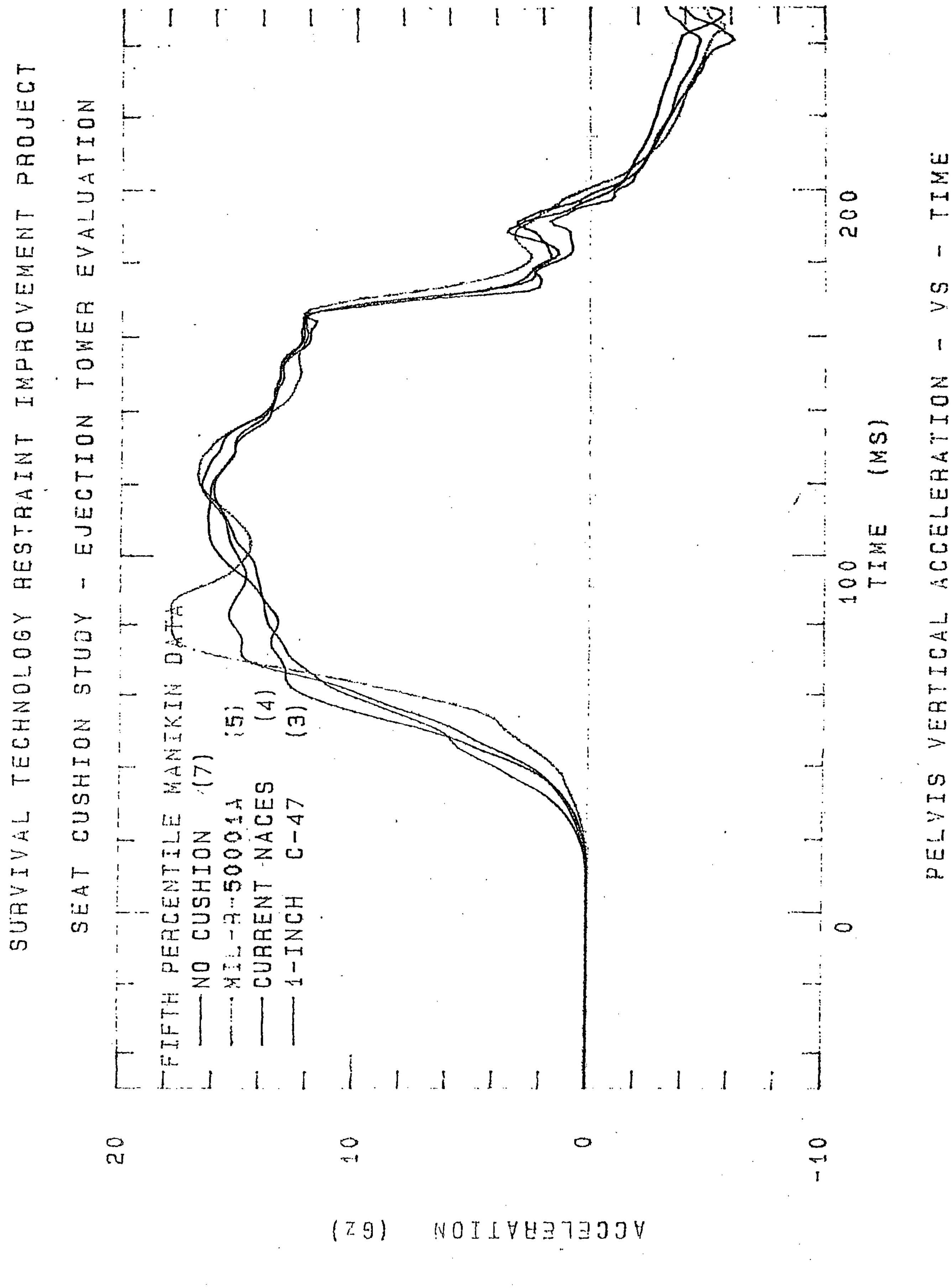

SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
ACCELERATION (GZ)
20
15
10
5
0
-5
0
100
200
TIME (MS)
CATAPULT VERTICAL ACCELERATION - VS - TIME

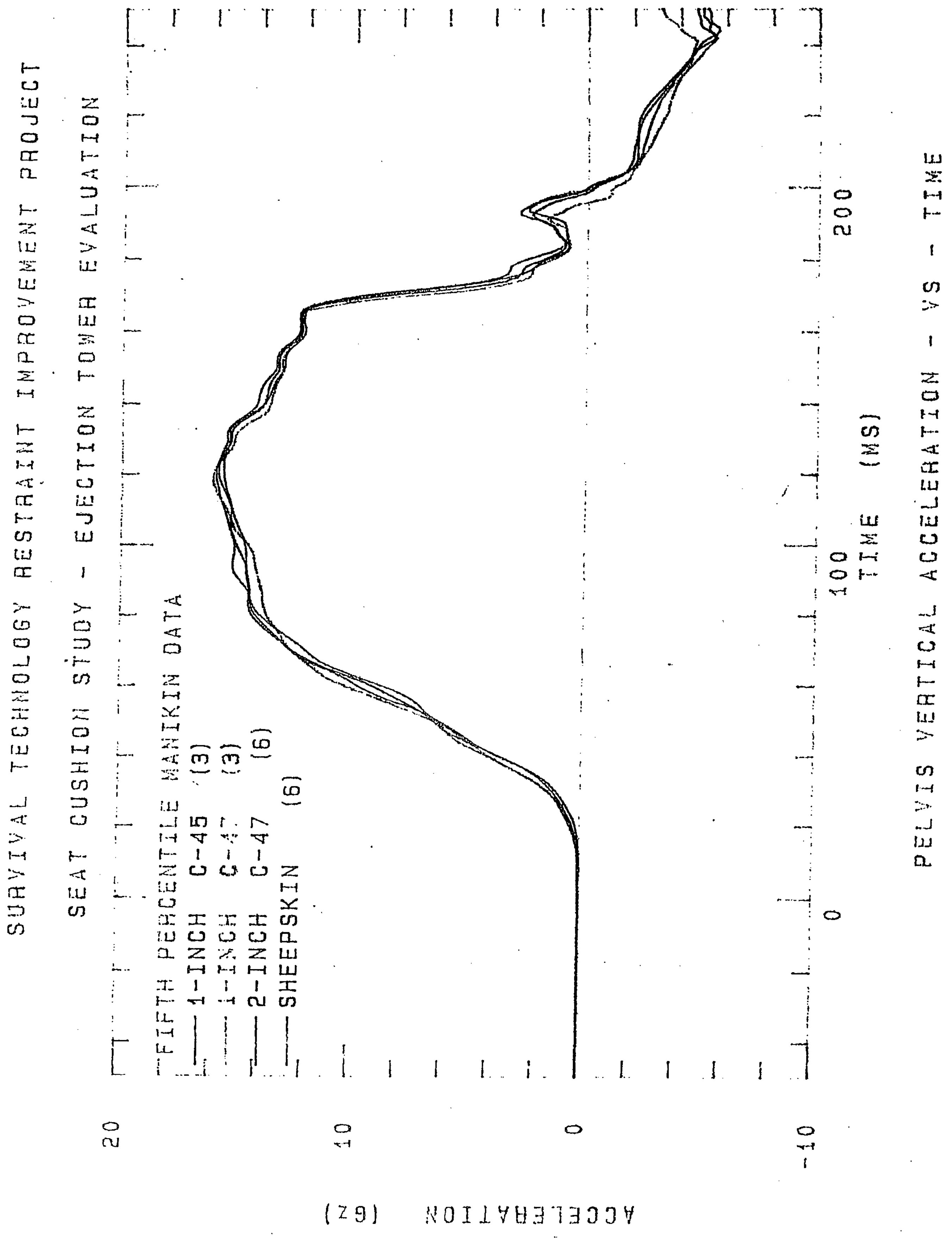
SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT

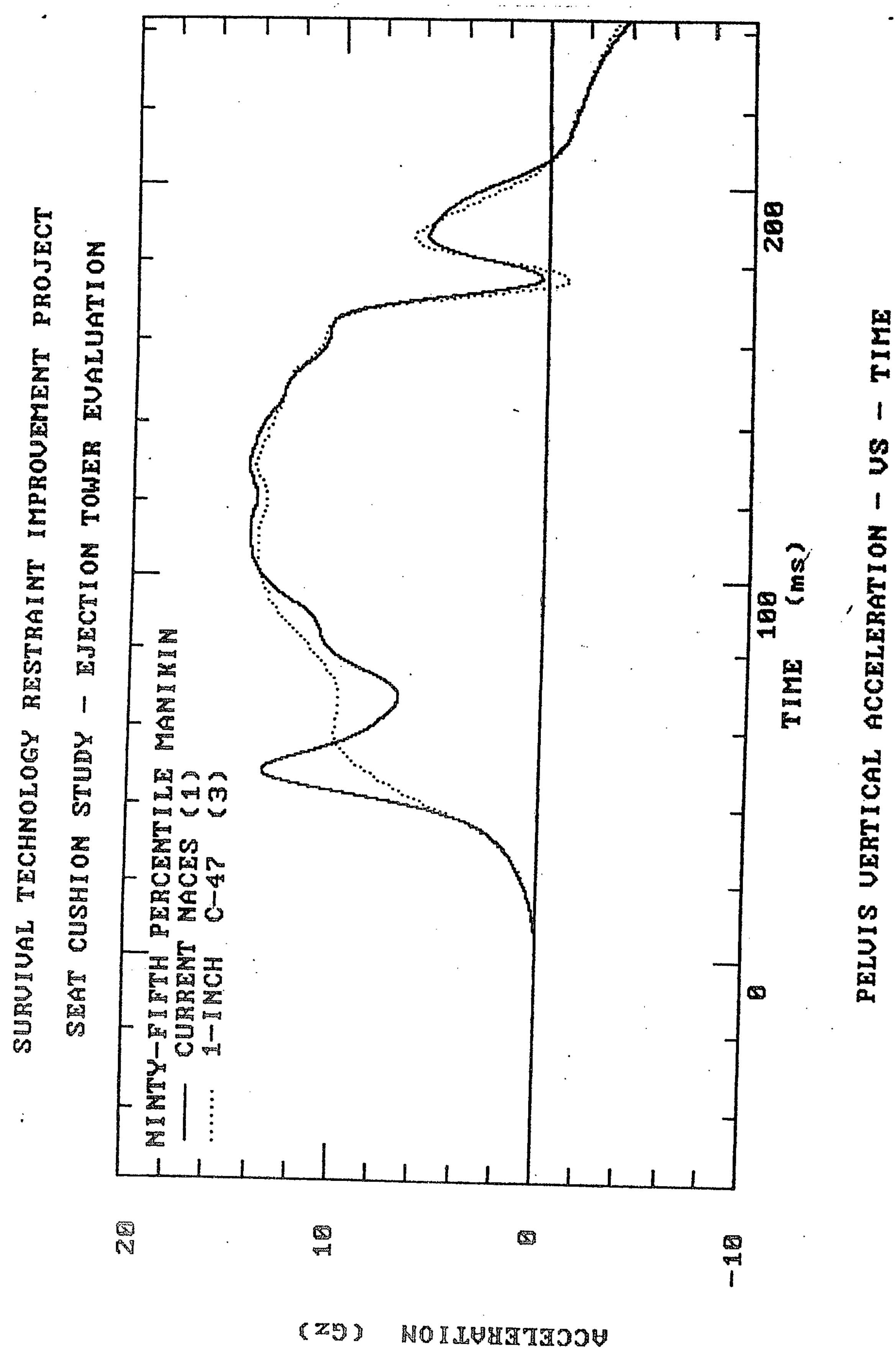
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION

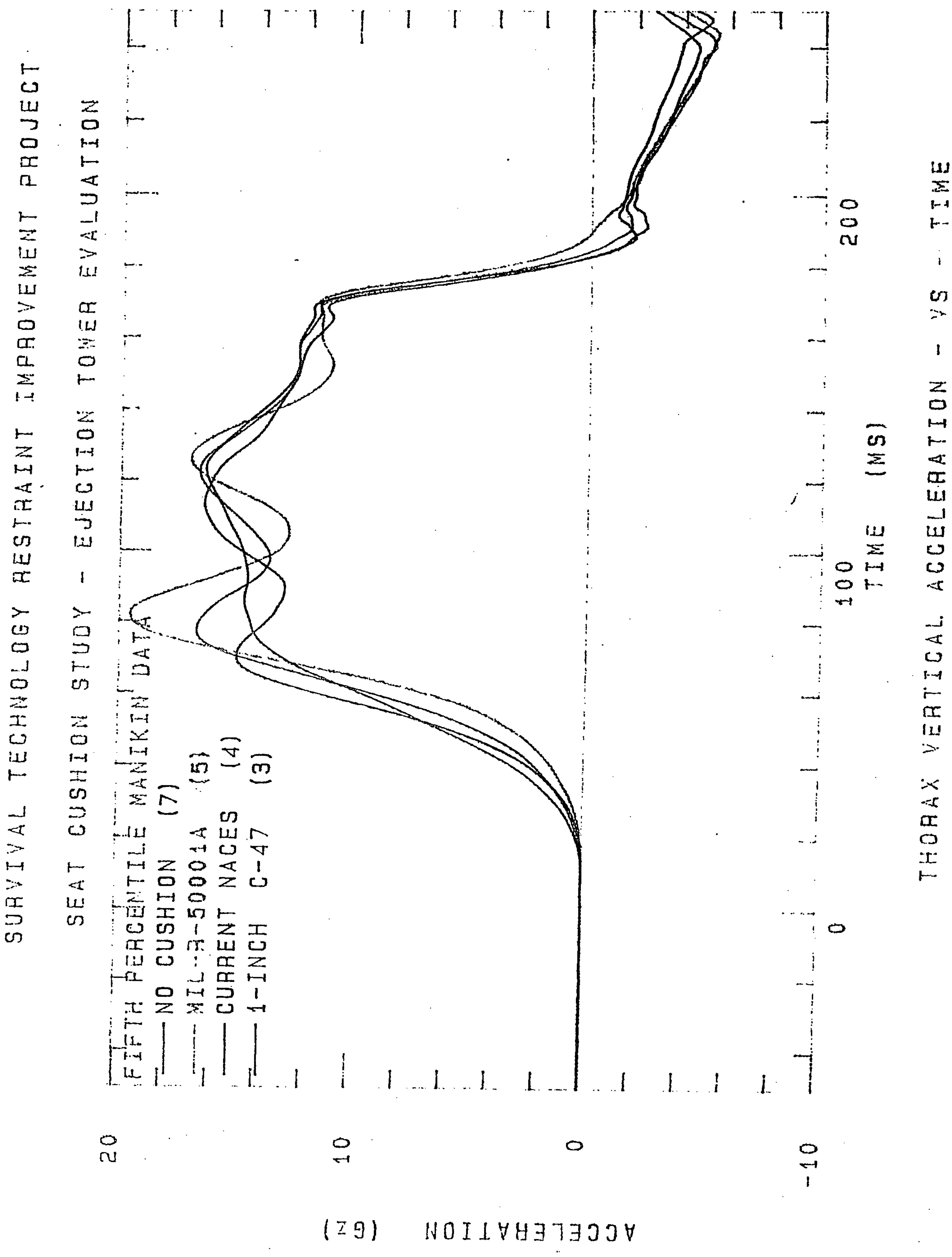


CATAPULT VERTICAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-5004A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
20
10
0
-10
ACCELERATION (GZ)
0
100
200
TIME (MS)
PELVIS VERTICAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
20
10
0
-10
ACCELERATION (Gz)
0
100
200
TIME (MS)
PELVIS VERTICAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
NINTY-FIFTH PERCENTILE MANIKIN
CURRENT NACES (1)
1-INCH C-47 (3)
ACCELERATION (Gz)
20
10
0
-10
0
100
200
TIME (ms)
PELVIS VERTICAL ACCELERATION - VS - TIME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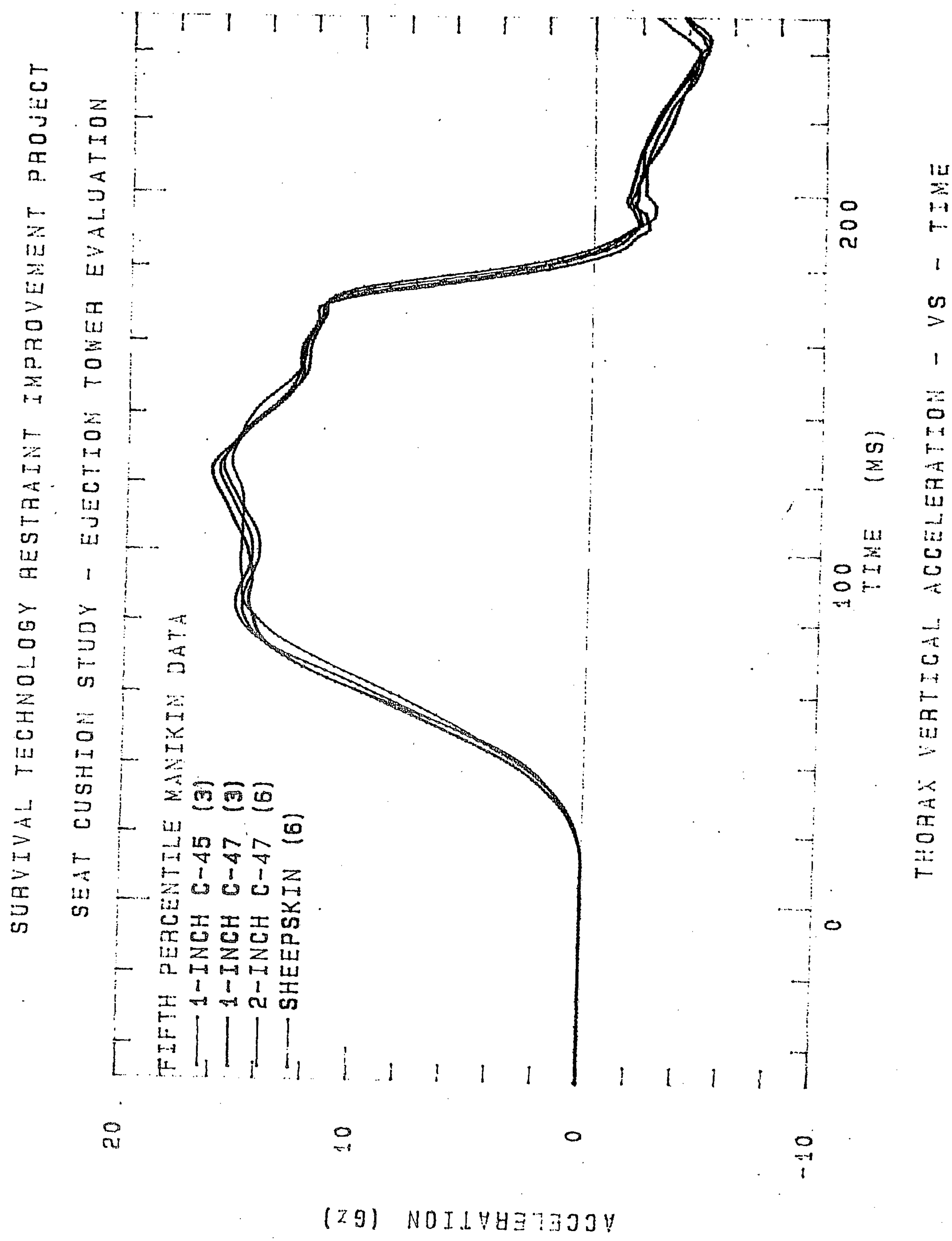
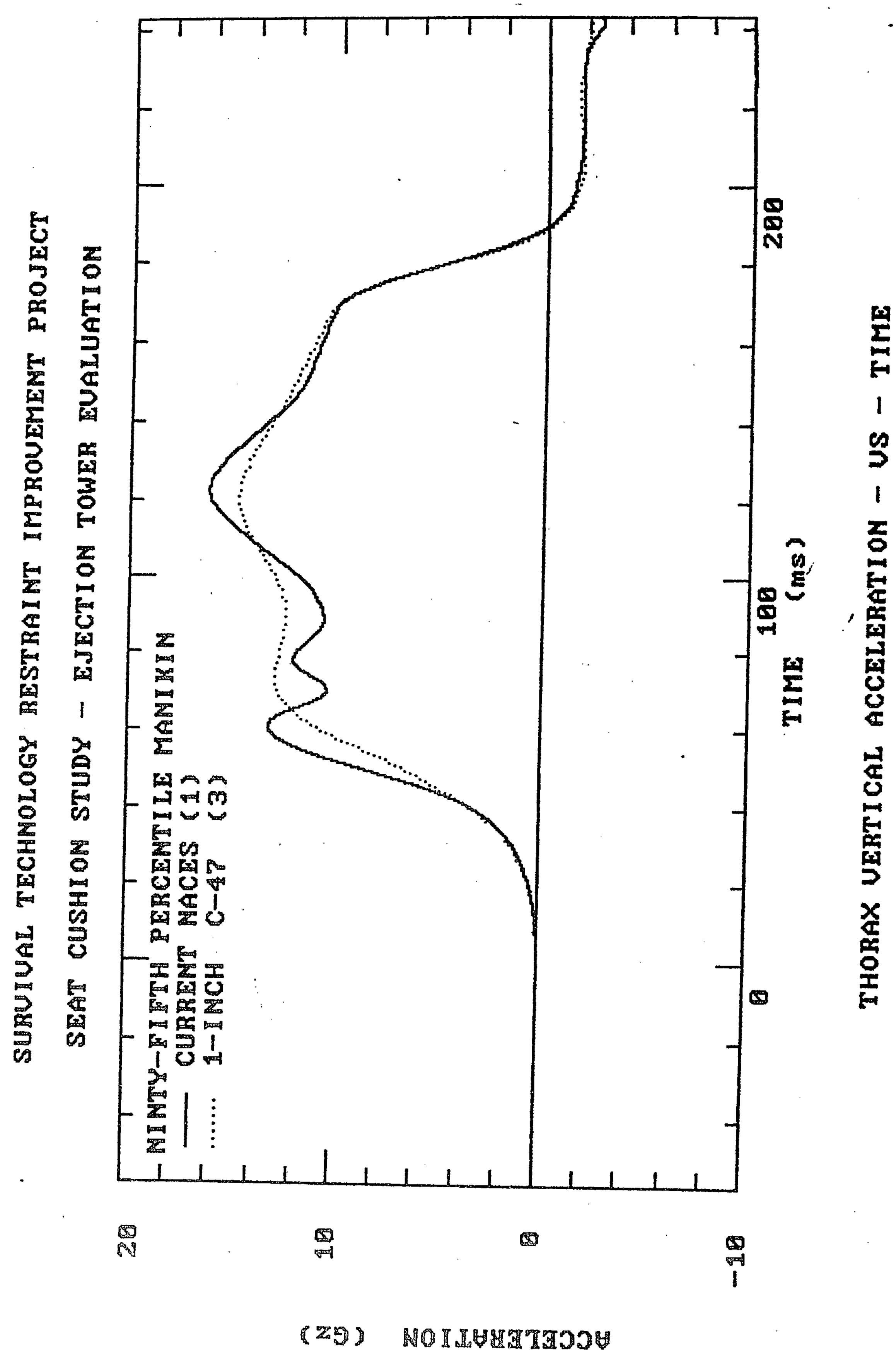
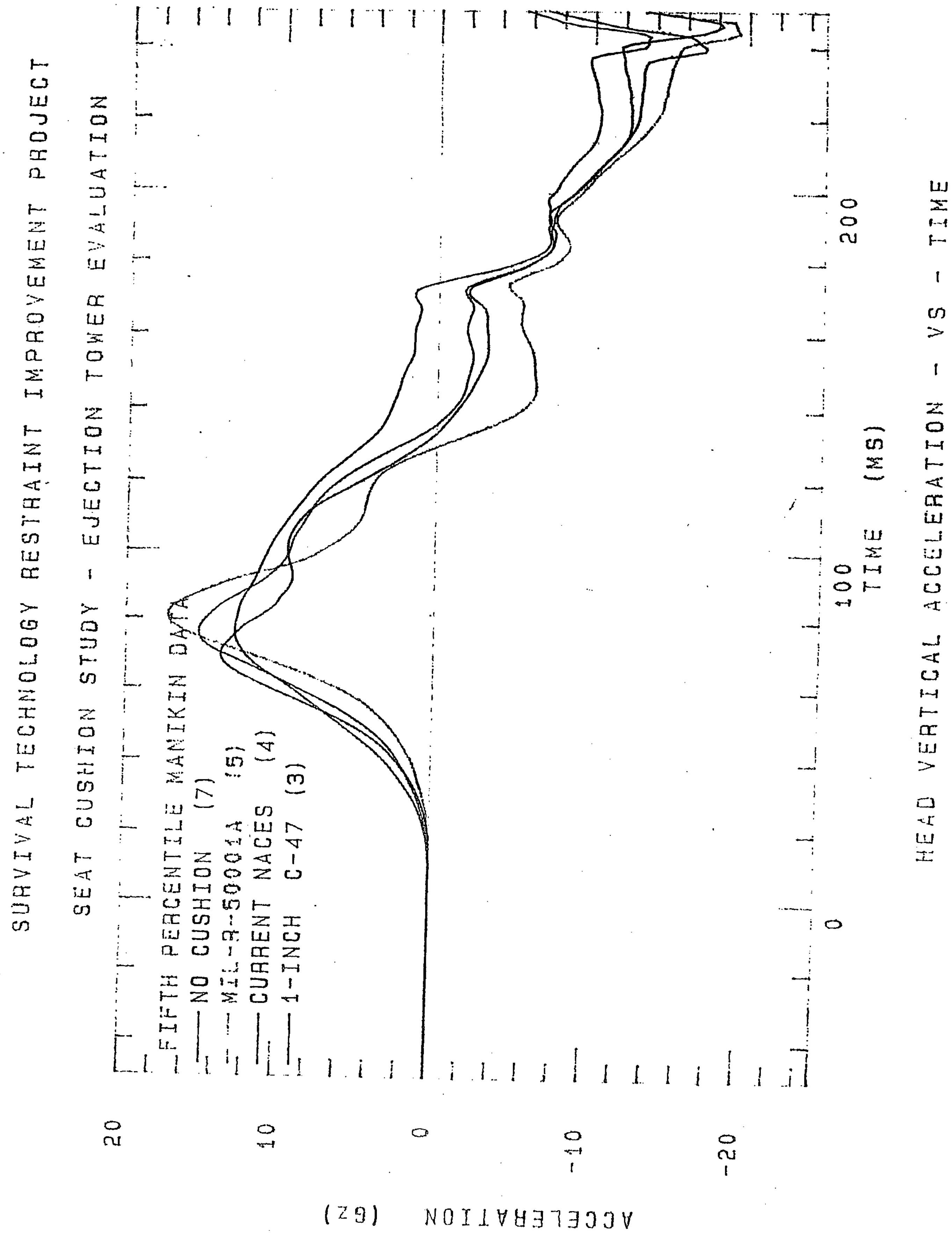
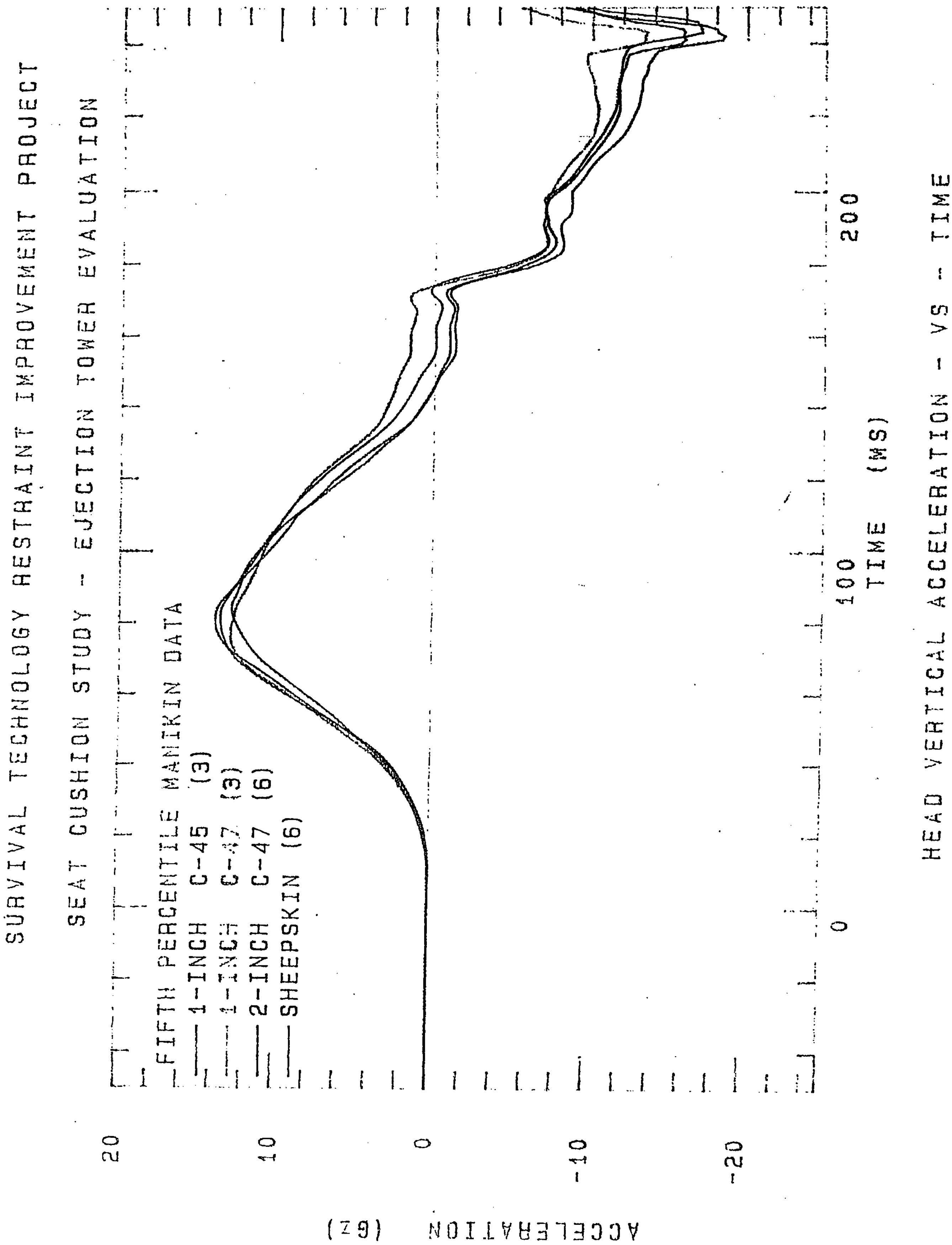
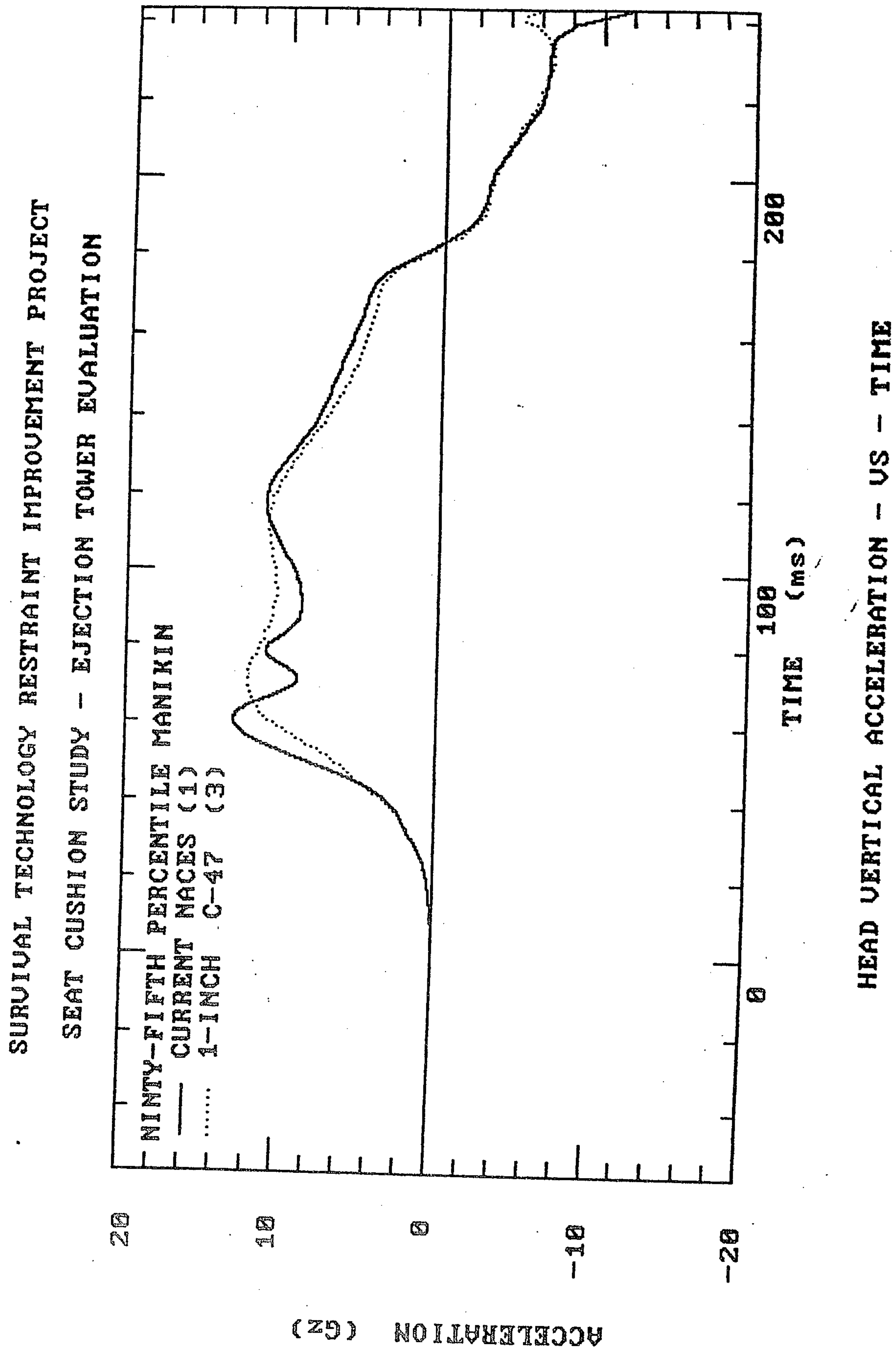
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-50001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
20
10
0
-10
ACCELERATION (Gz)
0
100
200
TIME (MS)
THORAX VERTICAL ACCELERATION - VS - TIME

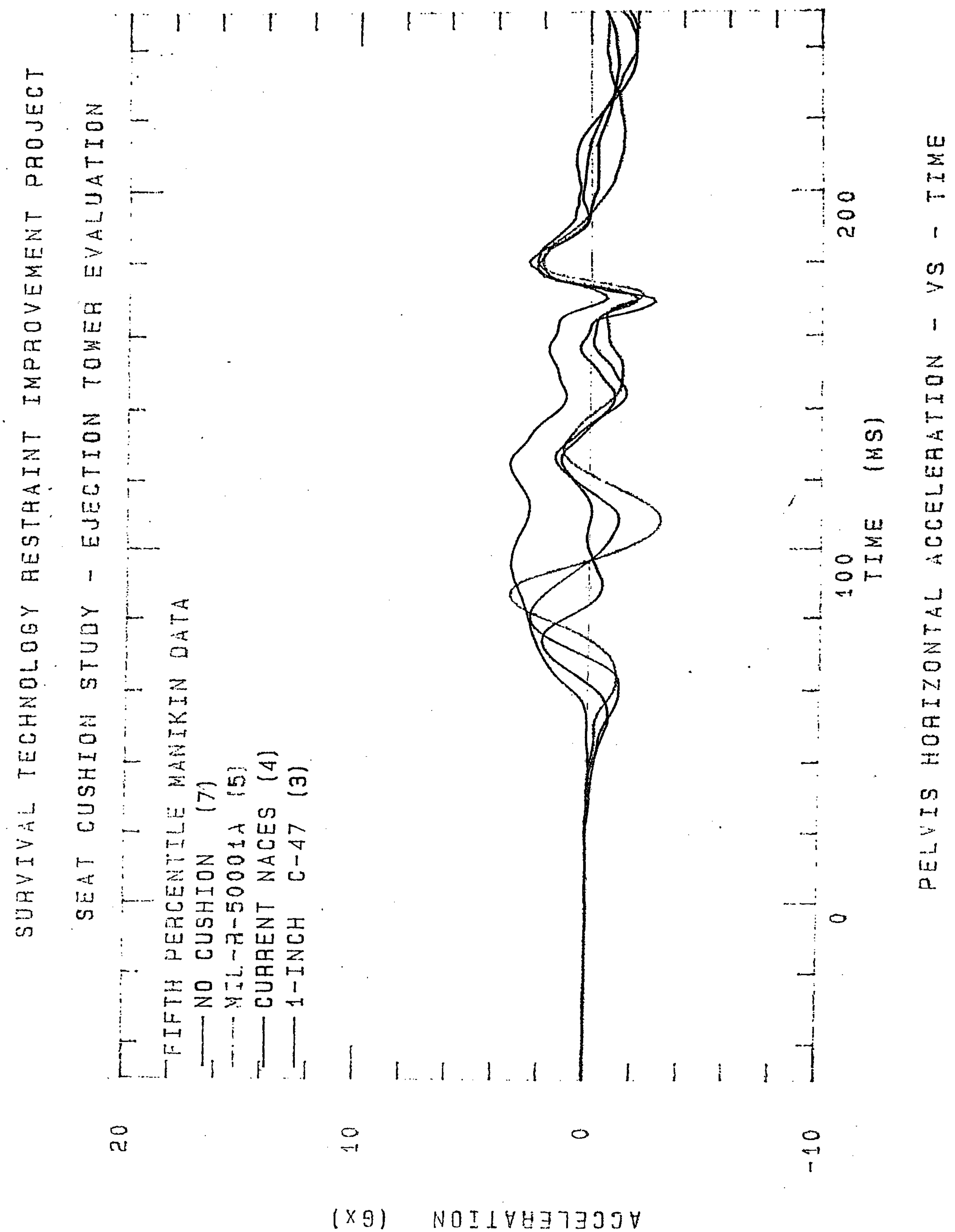

SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
20
10
0
-10
ACCELERATION (Gz)
0
100
200
TIME (MS)
THORAX VERTICAL ACCELERATION - VS - TIME

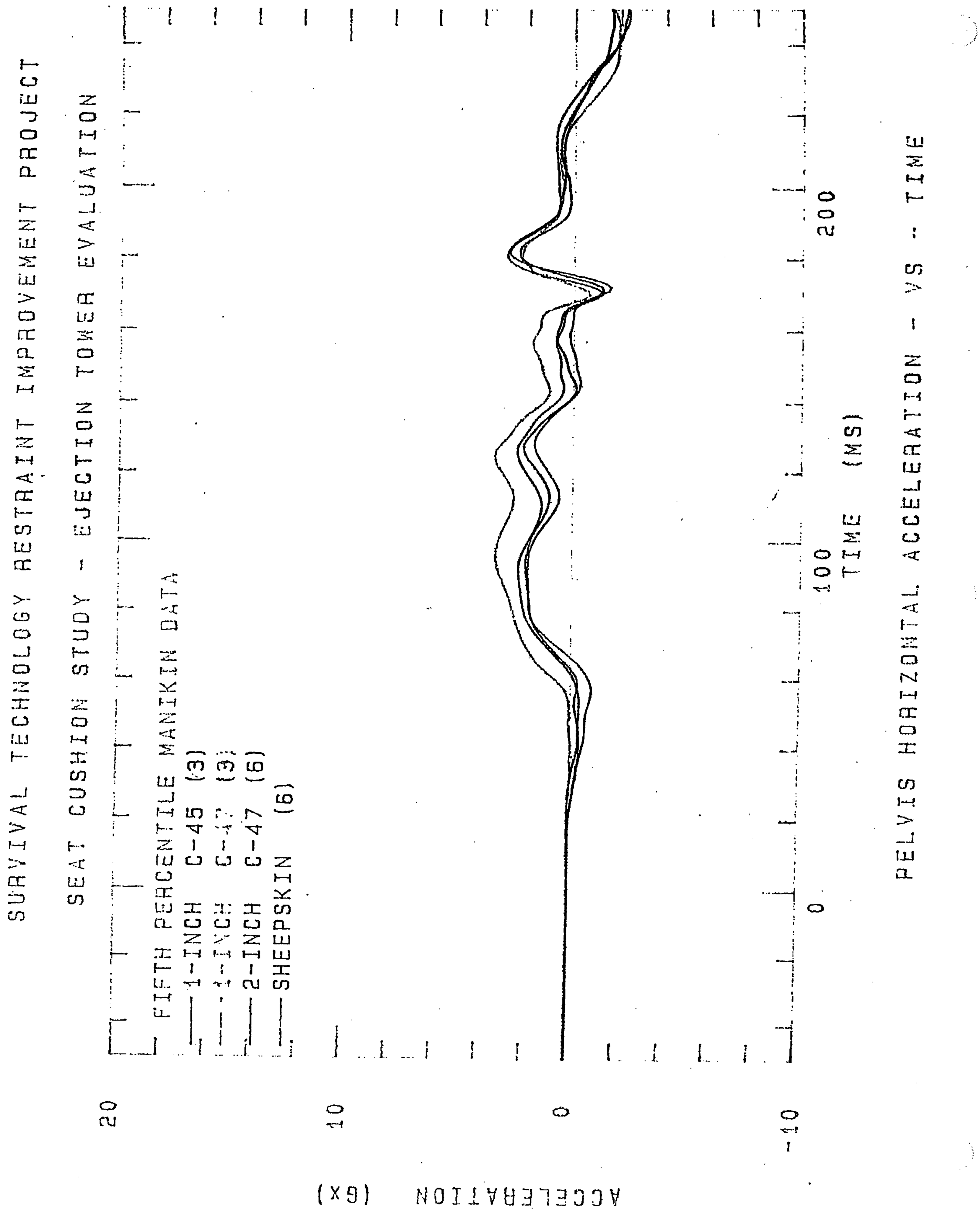

SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
NINTY-FIFTH PERCENTILE MANIKIN
CURRENT NACES (1)
1-INCH C-47 (3)
20
10
0
-10
ACCELERATION (Gz)
0
100
200
TIME (ms)
THORAX VERTICAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-50001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
20
10
0
-10
-20
ACCELERATION (Gz)
0
100
200
TIME (MS)
HEAD VERTICAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
20
10
0
-10
-20
ACCELERATION (Gz)
0
100
200
TIME (MS)
HEAD VERTICAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
NINTY-FIFTH PERCENTILE MANIKIN
CURRENT NACES (1)
1-INCH C-47 (3)
20
10
0
-10
-20
ACCELERATION (Gz)
0
100
200
TIME (ms)
HEAD VERTICAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-50001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
20
10
0
-10
ACCELERATION (GX)
0
100
200
TIME (MS)
PELVIS HORIZONTAL ACCELERATION - VS - TIME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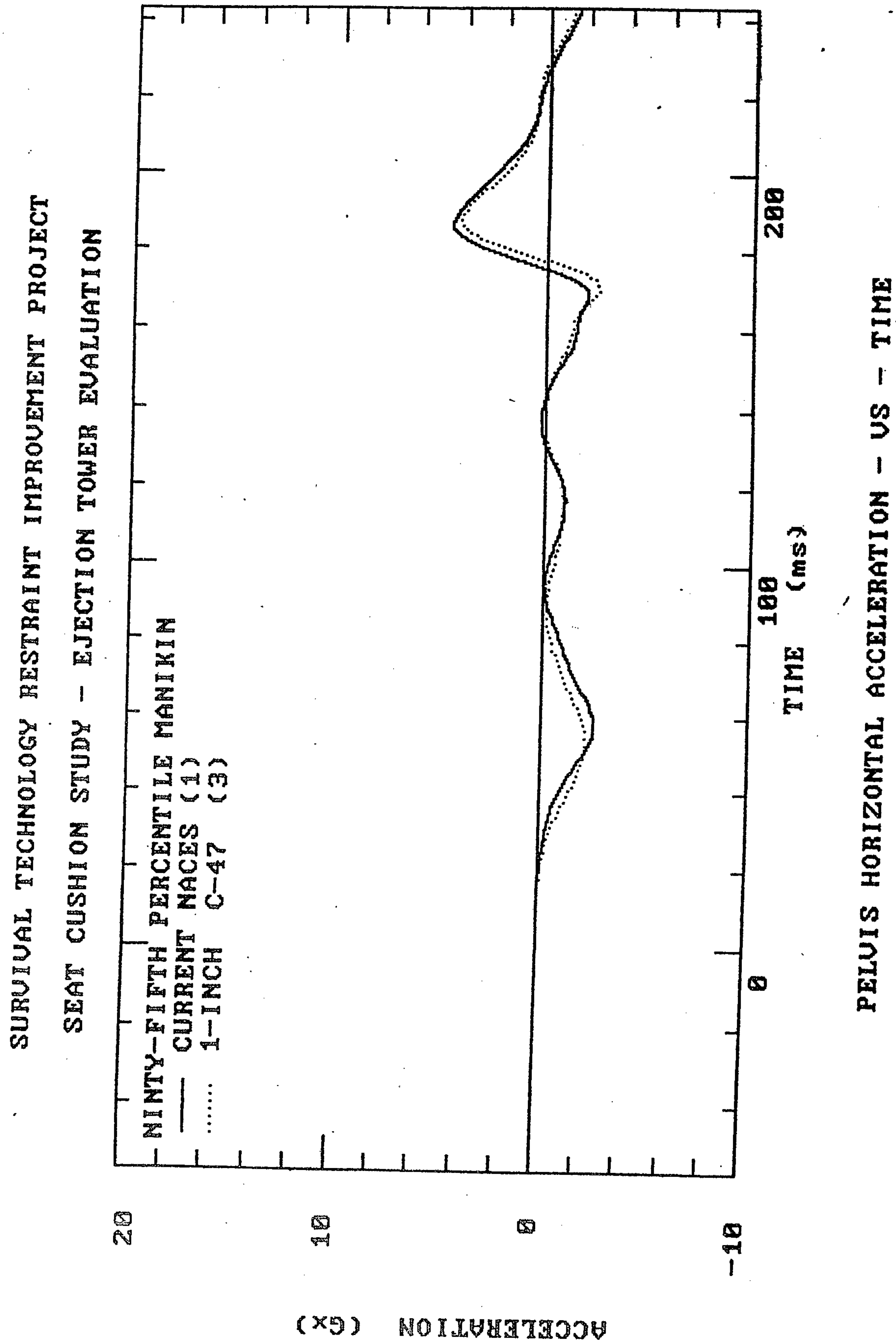
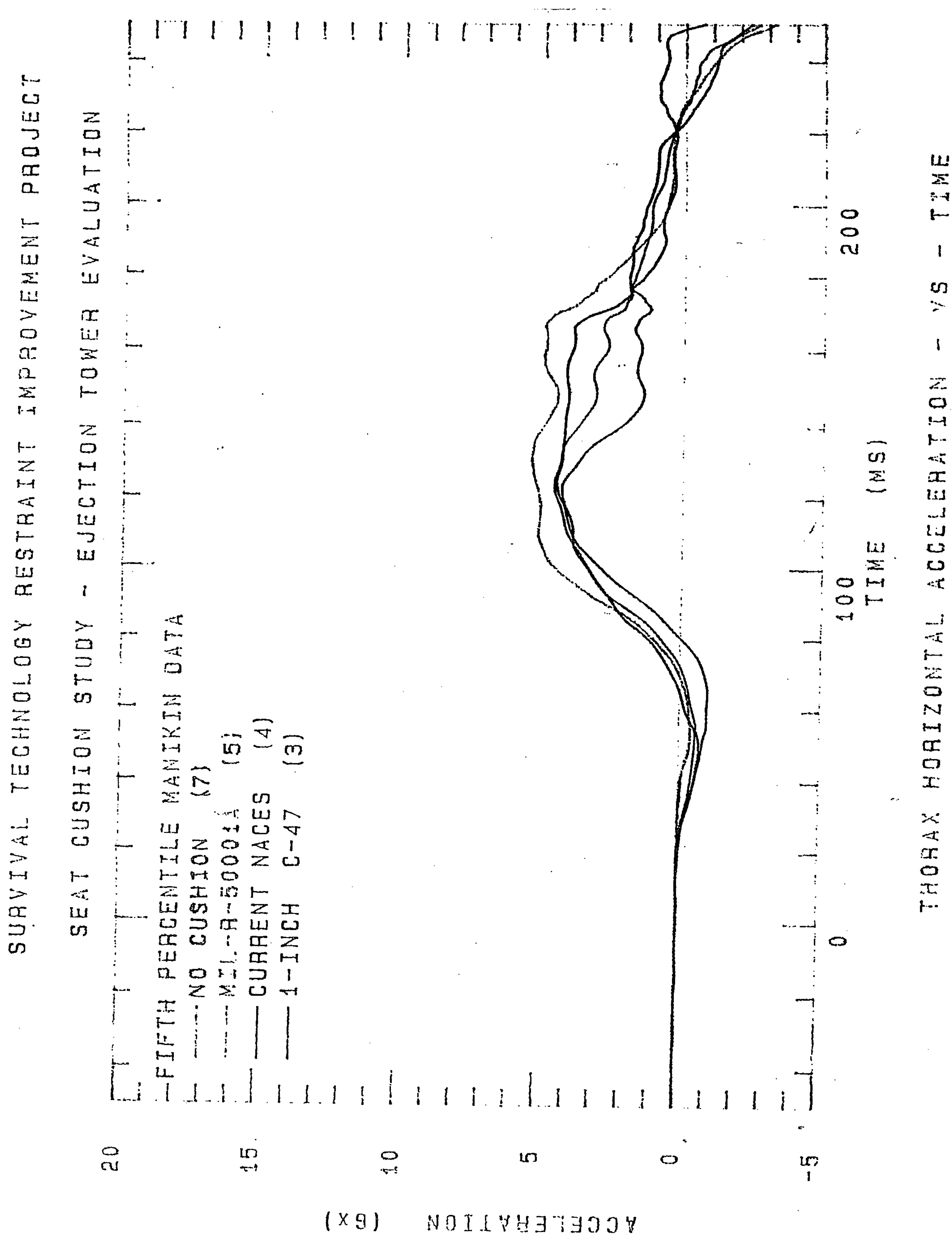
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-4 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
20
10
0
-10
ACCELERATION (GX)
0
100
200
TIME (MS)
PELVIS HORIZONTAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
NINTY-FIFTH PERCENTILE MANIKIN
CURRENT NACES (1)
1-INCH C-47 (3)
ACCELERATION (Gx)
20
10
0
-10
0
100
200
TIME (ms)
PELVIS HORIZONTAL ACCELERATION - VS - TIME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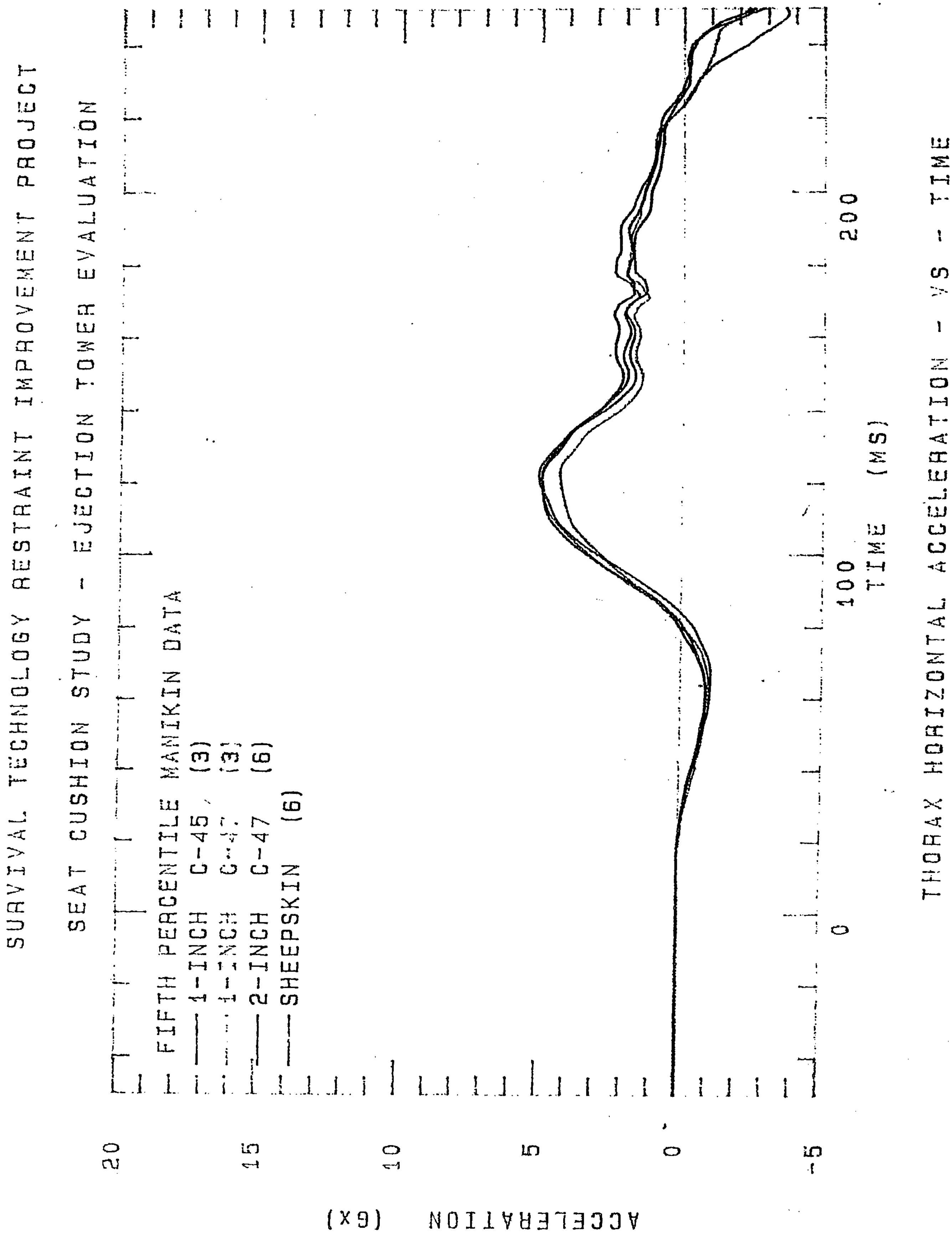
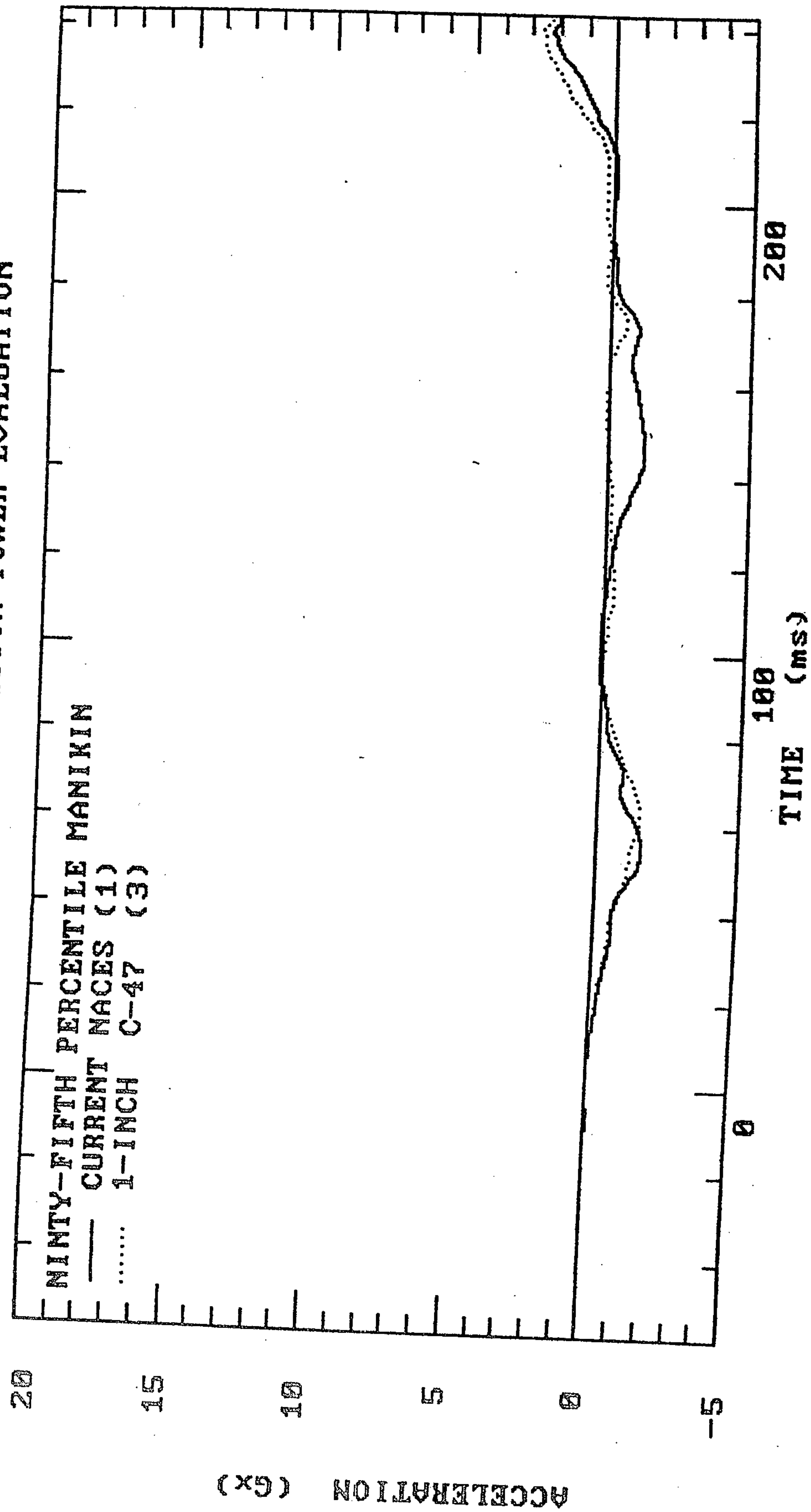
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-5001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
20
15
10
5
0
-5
ACCELERATION (GX)
0
100
200
TIME (MS)
THORAX HORIZONTAL ACCELERATION - VS - TIME

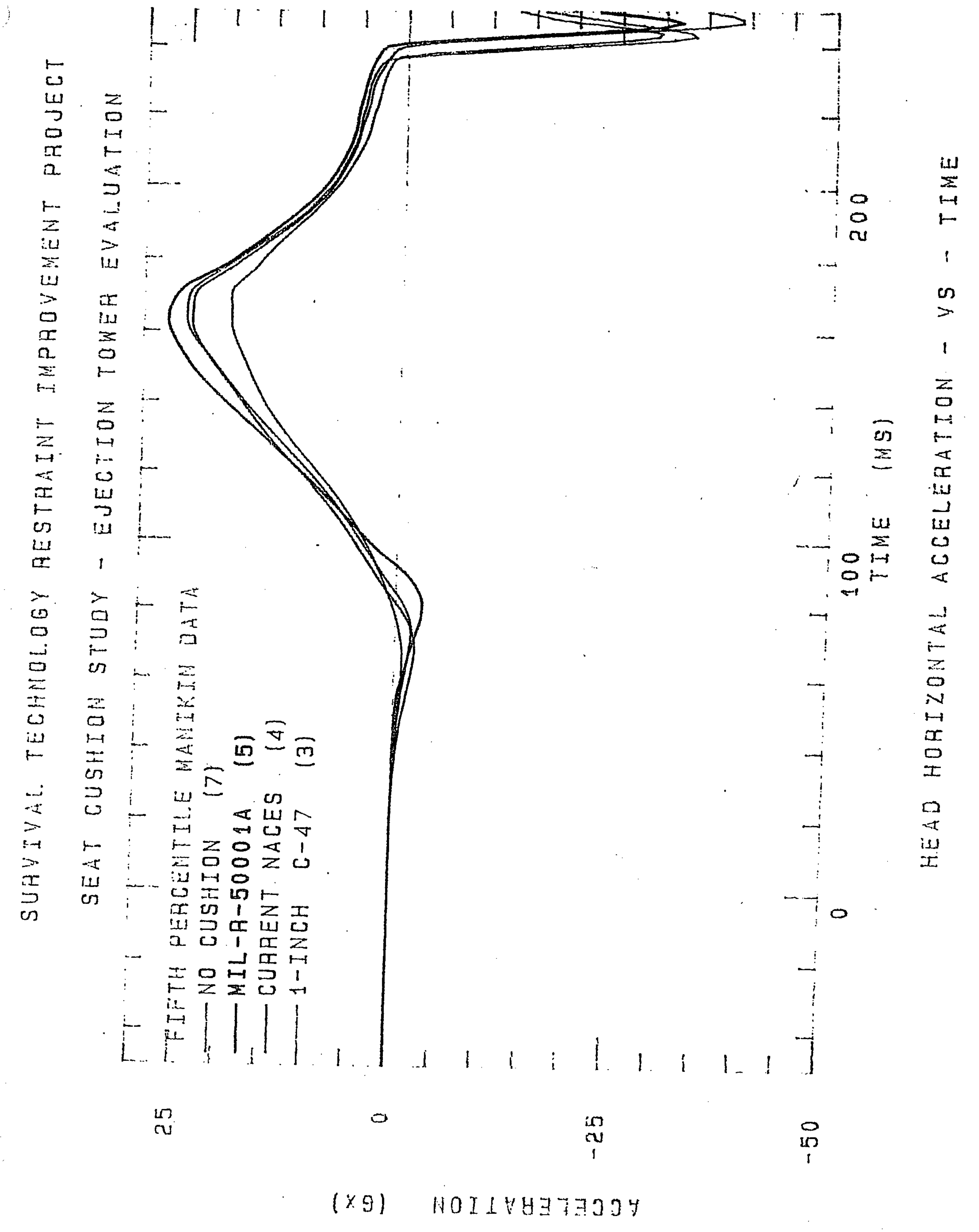

SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
20
15
10
5
0
-5
ACCELERATION (GX)
0
100
200
TIME (MS)
THORAX HORIZONTAL ACCELERATION - VS - TIME

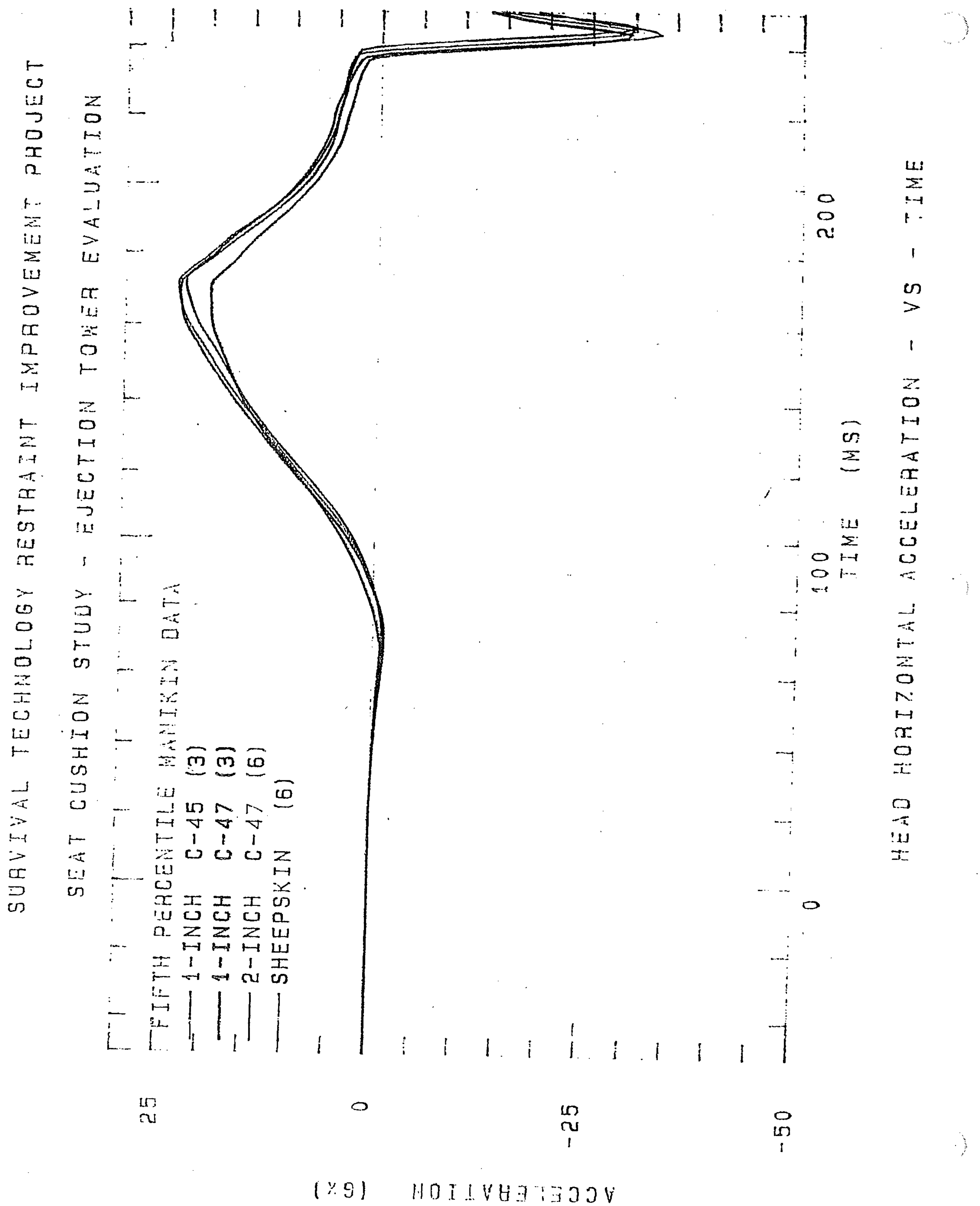
SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT

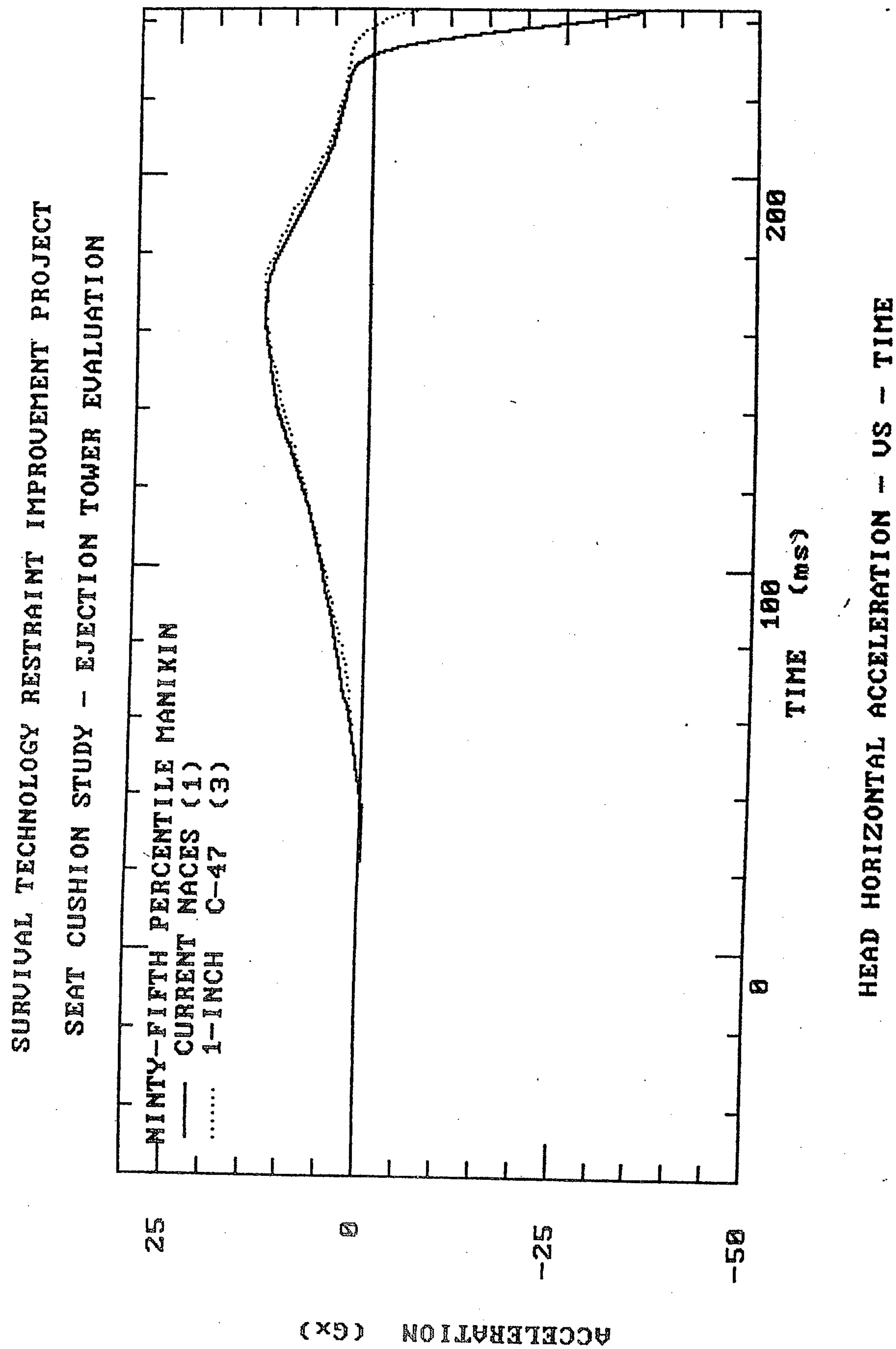
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION

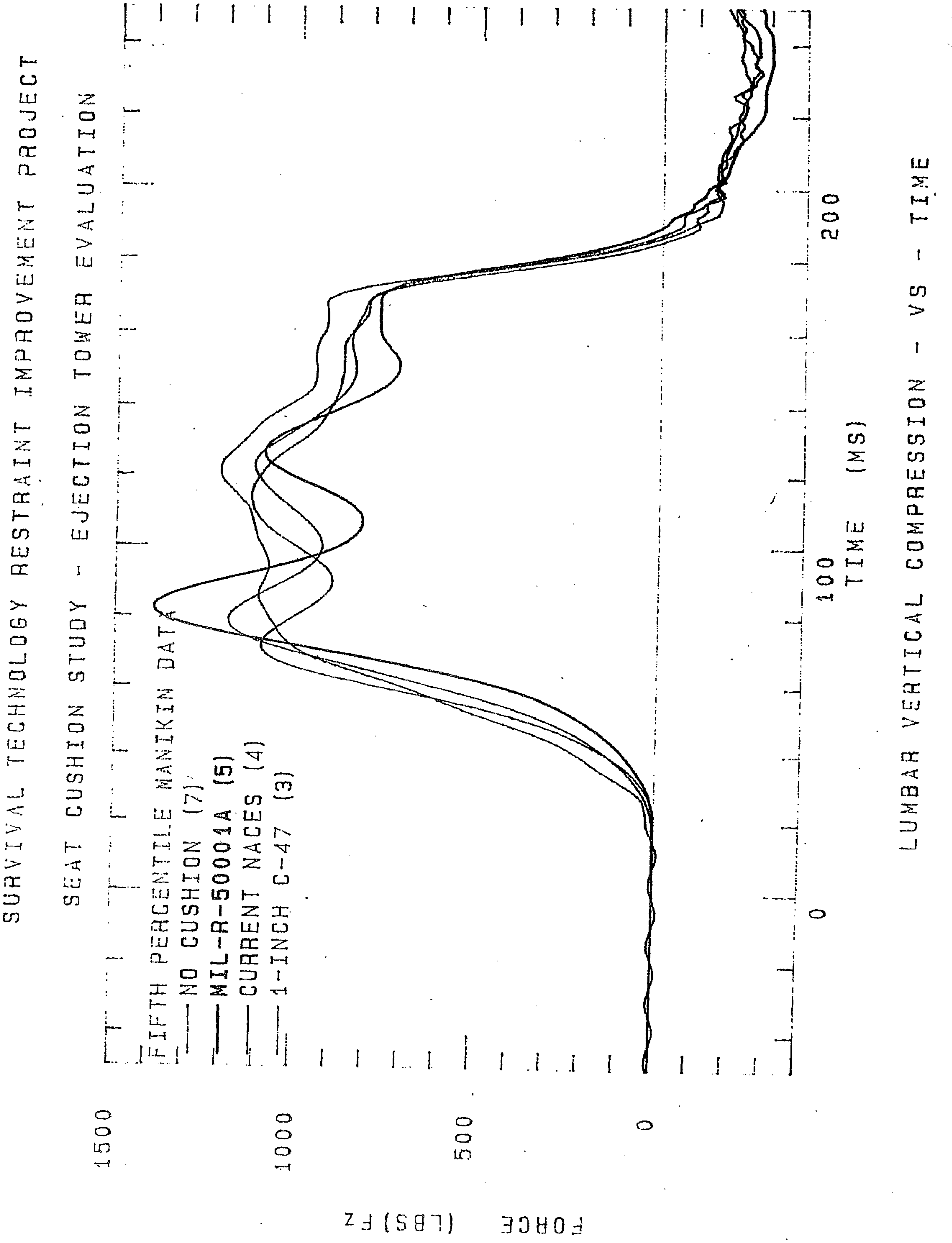


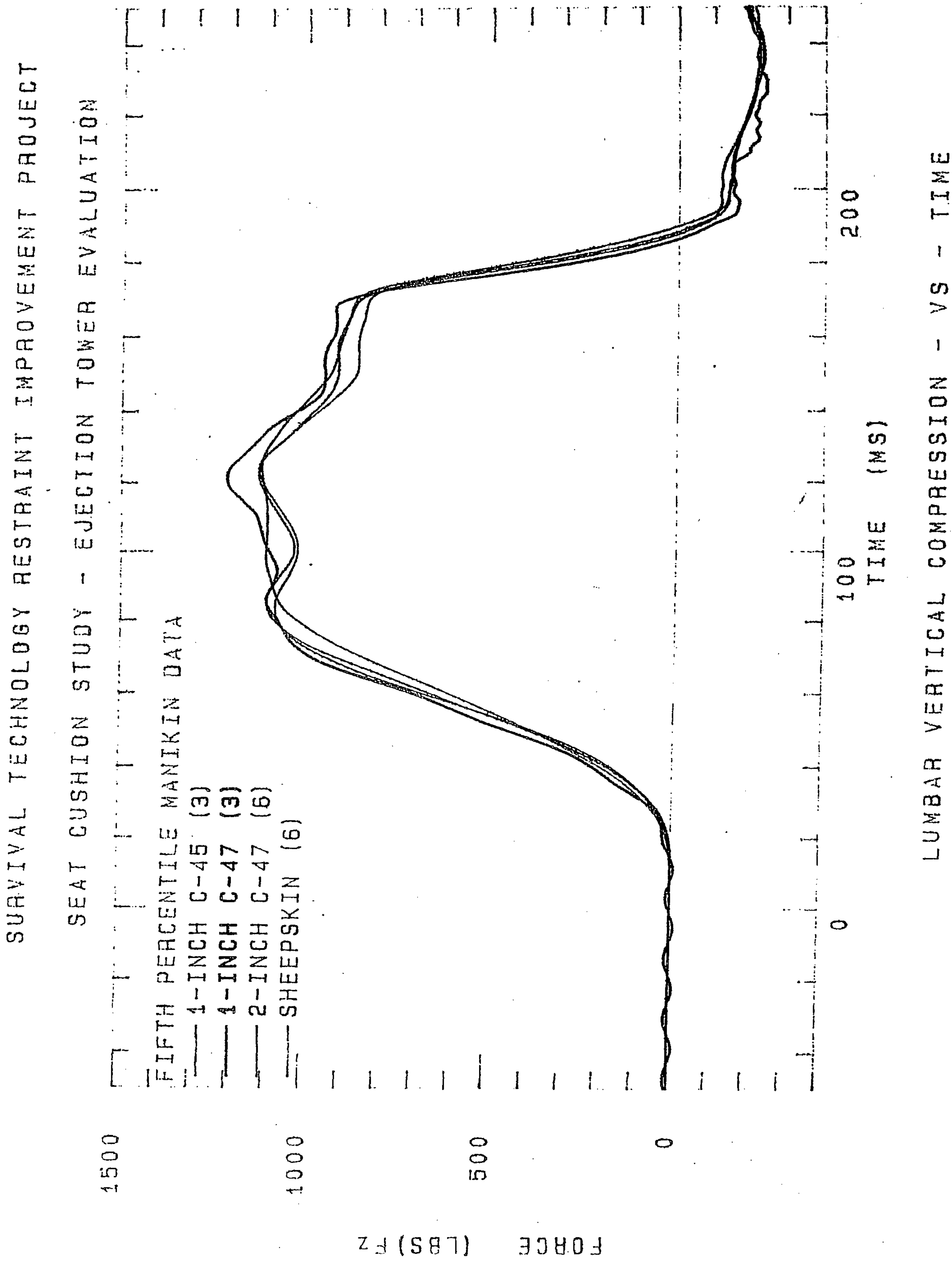
THORAX HORIZONTAL ACCELERATION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-50001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
25
0
-25
-50
ACCELERATION (GX)
0
100
200
TIME (MS)
HEAD HORIZONTAL ACCELERATION - VS - TIME

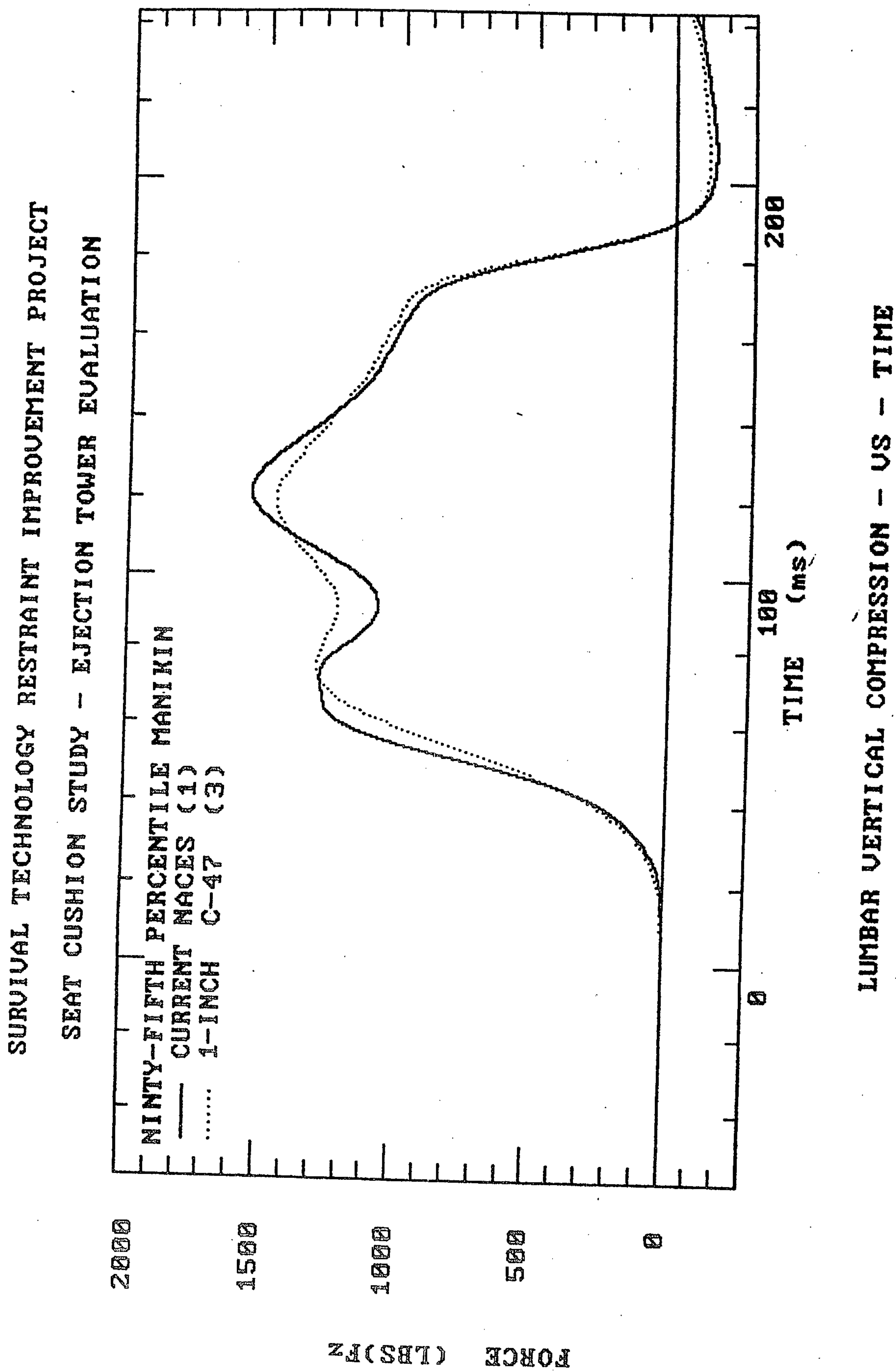

SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
25
0
-25
-50
ACCELERATION (G'S)
0
100
200
TIME (MS)
HEAD HORIZONTAL ACCELERATION - VS - TIME

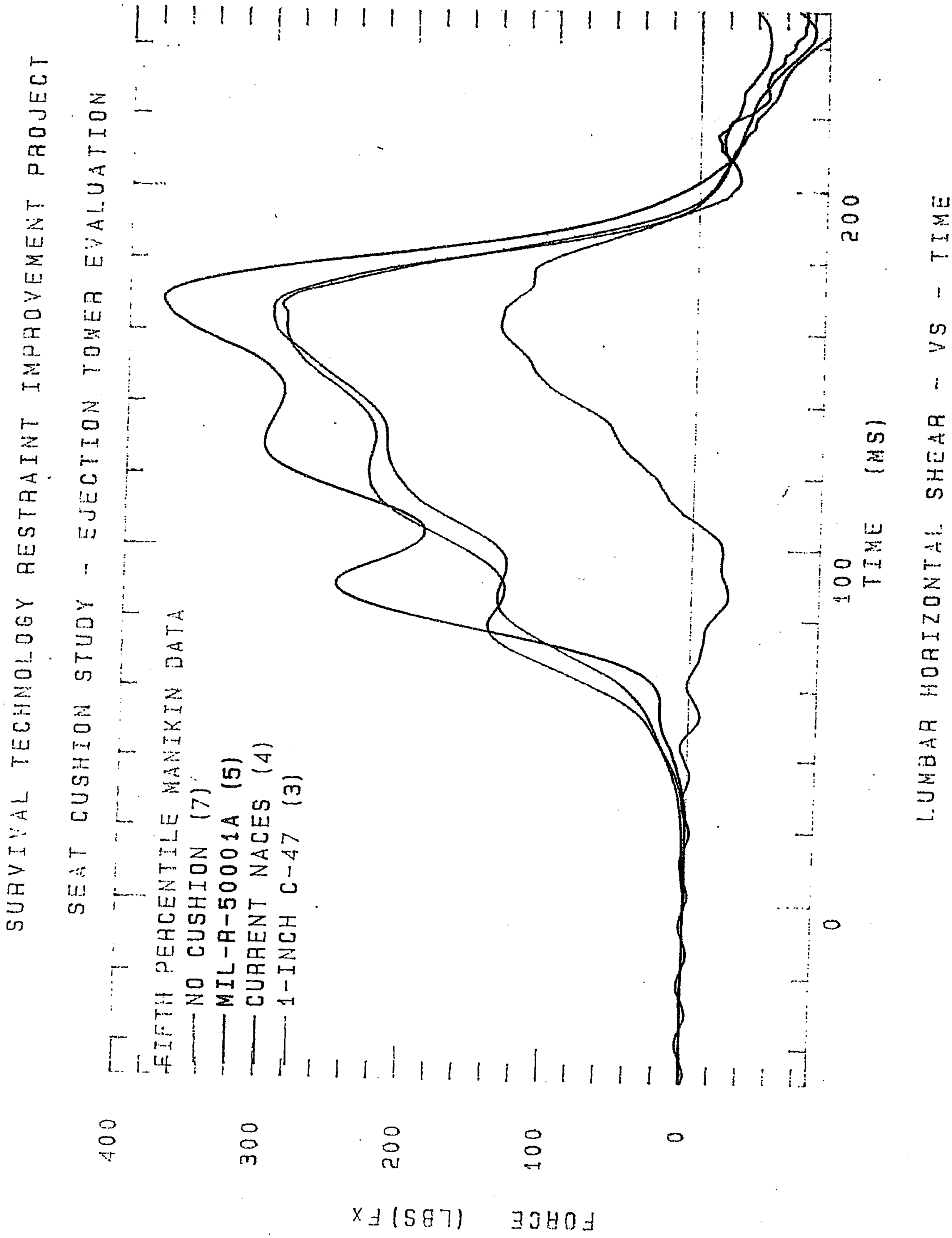

SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
NINTY-FIFTH PERCENTILE MANIKIN
CURRENT NACES (1)
1-INCH C-47 (3)
25
0
-25
-50
ACCELERATION (Gx)
0
100
200
TIME (ms)
HEAD HORIZONTAL ACCELERATION - US - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-50001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
1500
1000
500
0
FORCE (LBS) FZ
0
100
200
TIME (MS)
LUMBAR VERTICAL COMPRESSION - VS - TIME



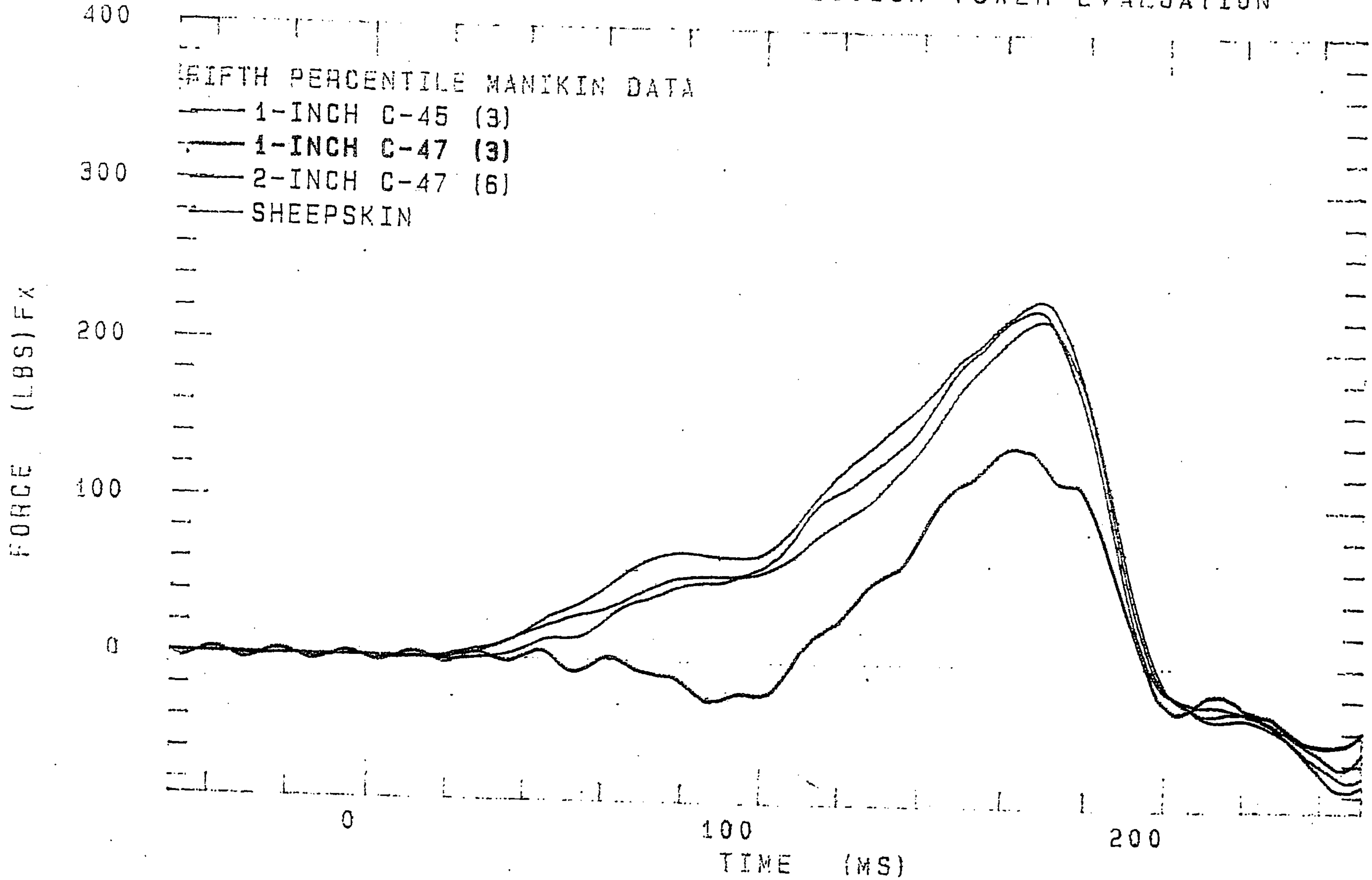
SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
1500
1000
500
0
FORCE (LBS) Fz
0
100
200
TIME (MS)
LUMBAR VERTICAL COMPRESSION - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
NINTY-FIFTH PERCENTILE MANIKIN
CURRENT NACES (1)
1-INCH C-47 (3)
2000
1500
1000
500
0
FORCE (LBS)Fz
0
100
200
TIME (ms)
LUMBAR VERTICAL COMPRESSION - VS - TIME

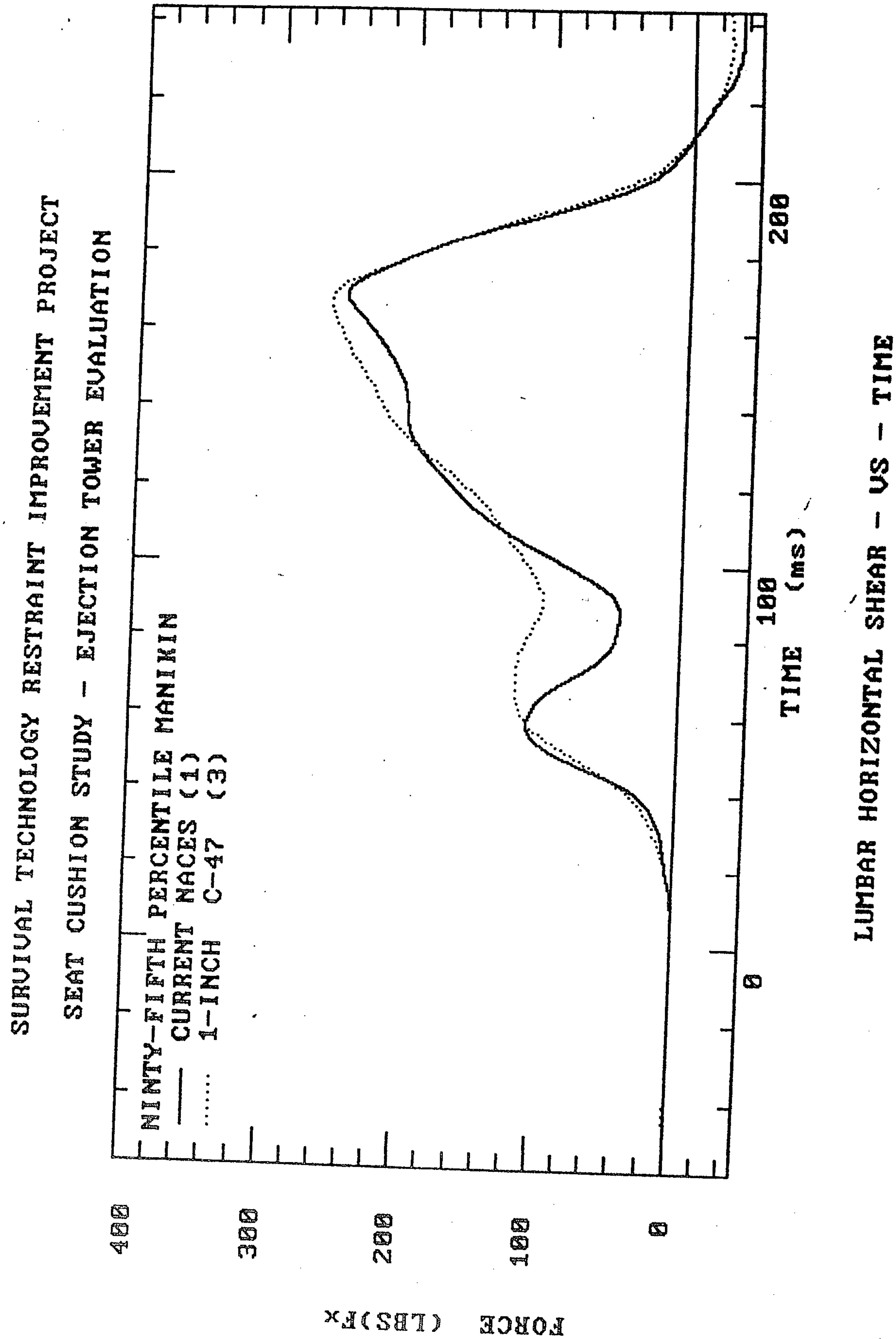

SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-50001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
400
300
200
100
0
FORCE (LBS) FX
0
100
200
TIME (MS)
LUMBAR HORIZONTAL SHEAR - VS - TIME

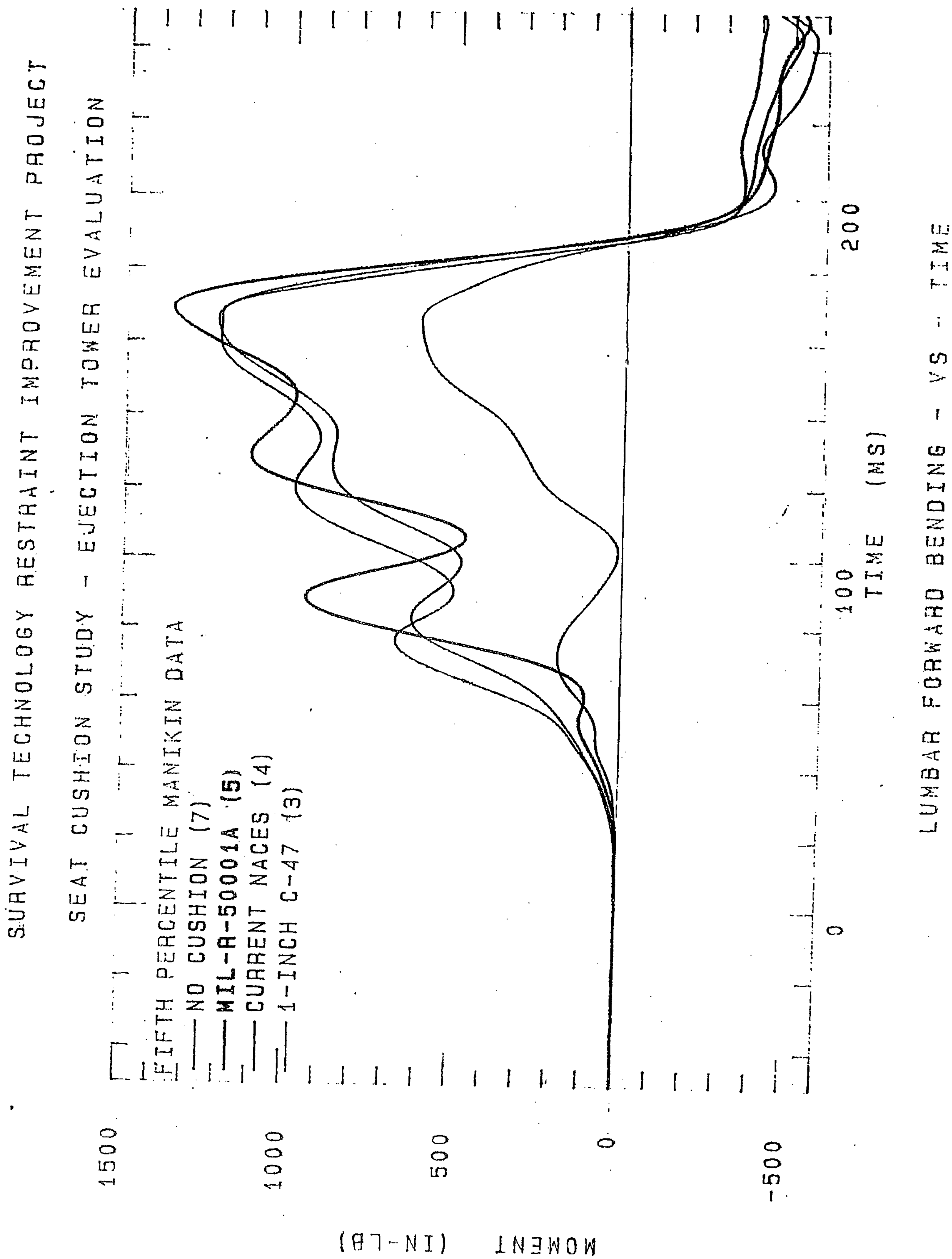
SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT

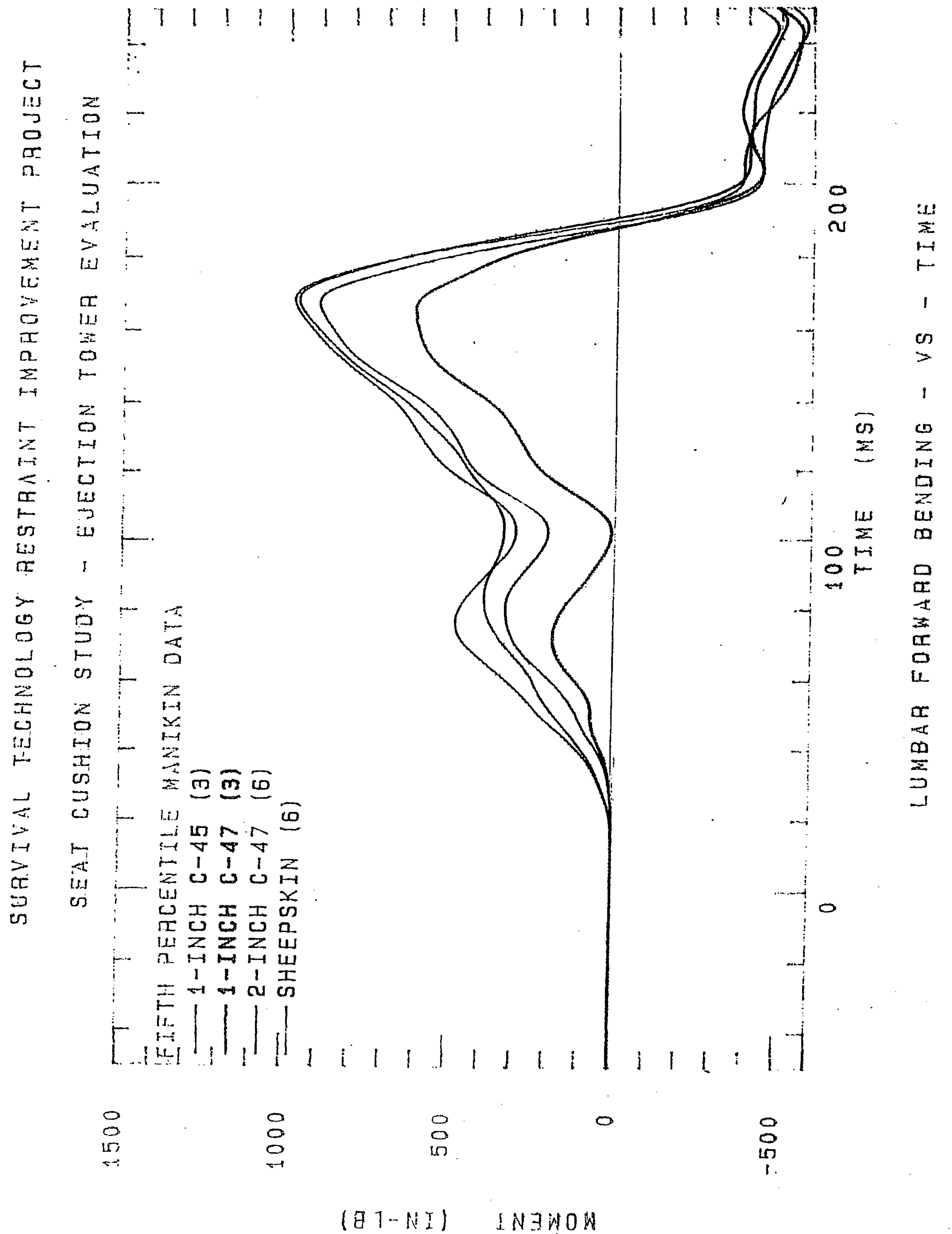
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION

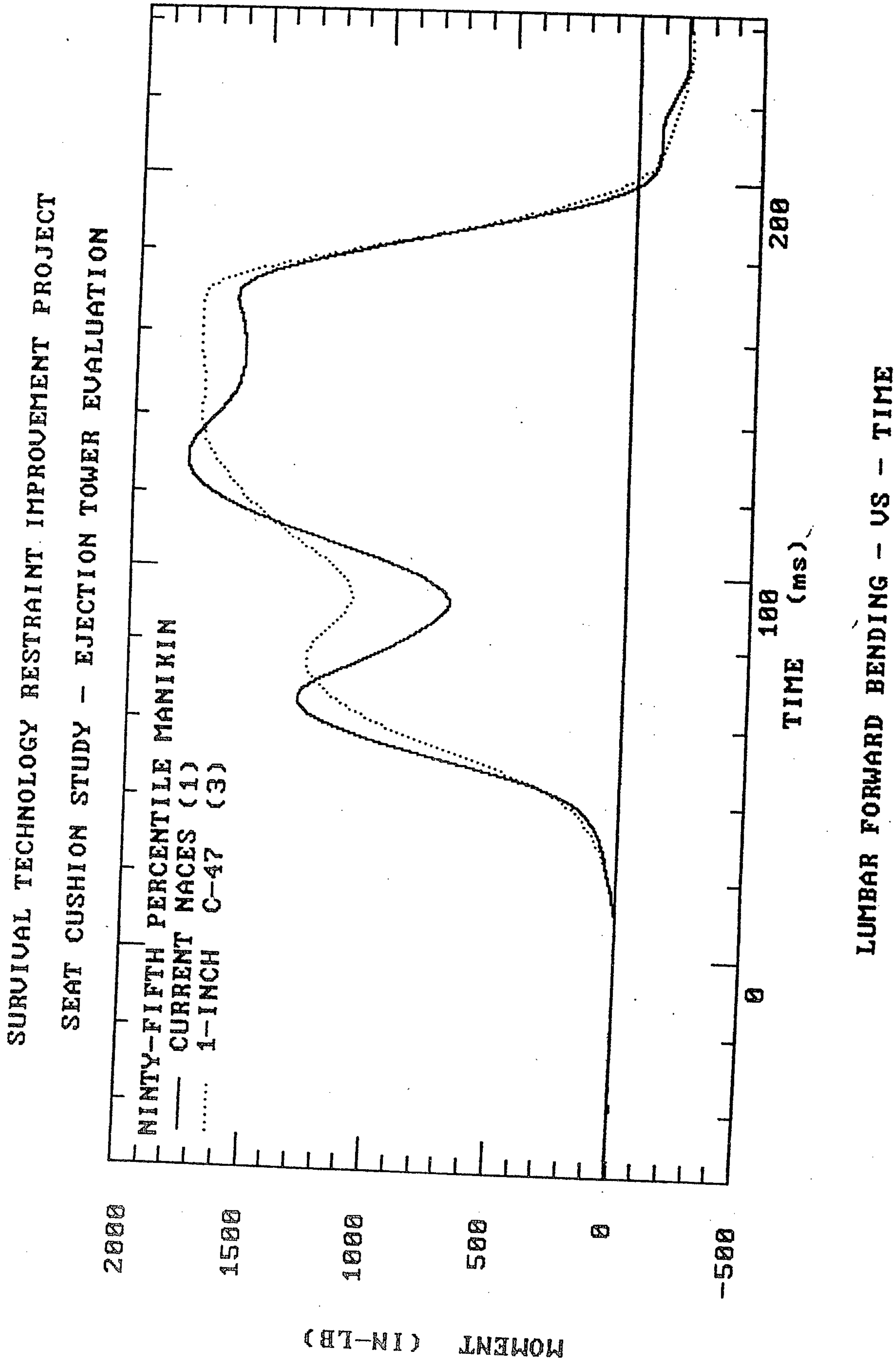


LUMBAR HORIZONTAL SHEAR - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
NINTY-FIFTH PERCENTILE MANIKIN
CURRENT NACES (1)
1-INCH C-47 (3)
400
300
200
100
0
FORCE (LBS)Fx
0
100
200
TIME (ms)
LUMBAR HORIZONTAL SHEAR - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
NO CUSHION (7)
MIL-R-50001A (5)
CURRENT NACES (4)
1-INCH C-47 (3)
MOMENT (IN-LB)
1500
1000
500
0
-500
0
100
200
TIME (MS)
LUMBAR FORWARD BENDING - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
FIFTH PERCENTILE MANIKIN DATA
1-INCH C-45 (3)
1-INCH C-47 (3)
2-INCH C-47 (6)
SHEEPSKIN (6)
1500
1000
500
0
-500
MOMENT (IN-LB)
0
100
200
TIME (MS)
LUMBAR FORWARD BENDING - VS - TIME


SURVIVAL TECHNOLOGY RESTRAINT IMPROVEMENT PROJECT
SEAT CUSHION STUDY - EJECTION TOWER EVALUATION
NINTY-FIFTH PERCENTILE MANIKIN
CURRENT NACES (1)
1-INCH C-47 (3)
2000
1500
1000
500
0
-500
MOMENT (IN-LB)
0
100
200
TIME (ms)
LUMBAR FORWARD BENDING - VS - TIME

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

PELVIS VERTICAL ACCELERATION

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (G)								
NONE	15.5	14.8	15.6	15.4	16.5	16.0	16.3	15.7	.6
MIL-R-5001A	17.2	16.1	16.3	18.9	17.8	18.1	16.1	17.2	1.1
NACES	15.9	16.2	16.2	16.6	16.1	15.1	15.8	16.0	.5
1 IN. C-45	15.5	16.7	15.9	15.7	16.9	-	-	16.1	.6
1 IN. C-47	15.7	15.3	16.1	16.2	16.6	16.0	-	16.0	.4
2 IN. C-47	15.0	15.4	15.2	15.1	15.0	15.6	-	15.2	.2
SHEEPSKIN	16.2	16.0	16.1	14.9	16.0	15.9	-	15.9	.5
	TIMES OF PEAK VALUE (msec)								
NONE	109	110	116	101	108	112	111	110	5
MIL-R-5001A	79	81	78	84	85	82	124	88	16
NACES	120	120	122	120	121	121	121	121	1
1 IN. C-45	120	117	120	121	121	-	-	120	2
1 IN. C-47	119	120	119	119	120	119	-	119	1
2 IN. C-47	121	119	116	119	120	122	-	120	2
SHEEPSKIN	119	121	119	120	120	121	-	120	1
	SEPERATION VELOCITY (FT/SEC)								
NONE	52.8	51.8	53.5	53.5	54.4	54.1	55.1	53.6	1.1
MIL-R-5001A	53.8	53.1	53.5	55.4	54.4	53.1	53.8	53.9	.8
NACES	53.8	54.7	54.4	55.1	54.4	52.8	53.8	54.1	.9
1 IN. C-45	53.5	55.1	54.1	53.8	56.0	-	-	54.5	1.0
1 IN. C-47	53.8	53.1	53.8	54.1	54.7	54.1	-	53.9	.5
2 IN. C-47	52.5	53.5	53.1	53.1	53.1	54.4	-	53.3	.6
SHEEPSKIN	54.4	54.7	54.4	52.5	54.4	54.1	-	54.1	.8

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

THORAX VERTICAL ACCELERATION

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (G)								
NONE	15.6	14.9	15.4	15.4	16.3	16.3	16.4	15.8	.6
MIL-R-5001A	18.0	16.6	17.2	20.9	19.6	19.4	17.3	18.4	1.6
NACES	16.7	18.1	16.9	16.7	17.0	15.8	15.9	16.7	.8
1 IN. C-45	15.7	16.6	16.0	15.5	16.8	-	-	16.1	.6
1 IN. C-47	15.6	15.2	16.4	16.0	16.5	15.9	-	15.9	.5
2 IN. C-47	15.3	15.8	15.4	15.3	15.2	15.5	-	15.4	.2
SHEEPSKIN	16.2	16.5	16.1	14.9	16.3	15.9	-	16.0	.6
	TIMES OF PEAK VALUE (msec)								
NONE	114	113	109	108	110	114	113	112	3
MIL-R-5001A	80	79	78	81	82	81	82	80	2
NACES	77	79	77	77	78	79	123	84	17
1 IN. C-45	124	121	123	121	124	-	-	123	2
1 IN. C-47	122	123	123	123	126	124	-	124	1
2 IN. C-47	125	123	122	125	126	125	-	124	2
SHEEPSKIN	123	83	125	123	125	125	-	117	17
	SEPERATION VELOCITY (FT/SEC)								
NONE	51.8	51.2	52.5	52.2	53.5	53.5	53.5	52.6	.9
MIL-R-5001A	51.5	50.6	50.9	53.5	52.5	50.9	52.8	51.8	1.1
NACES	52.8	54.1	53.5	53.8	53.8	51.5	52.2	53.1	1.0
1 IN. C-45	53.1	54.1	53.5	53.1	53.8	-	-	53.5	.4
1 IN. C-47	53.1	52.5	53.8	53.5	53.5	52.5	-	53.2	.6
2 IN. C-47	52.8	53.8	53.1	53.1	52.8	53.1	-	53.1	.4
SHEEPSKIN	53.5	53.8	53.8	51.5	53.8	53.1	-	53.3	.9

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

HEAD VERTICAL ACCELERATION

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (G)								
NONE	11.1	11.6	11.6	12.5	12.5	13.1	13.8	12.3	1.0
MIL-R-5001A	16.1	13.9	15.3	18.5	17.3	17.2	15.9	16.3	1.5
NACES	15.3	17.0	15.6	15.3	16.1	14.2	14.0	15.4	1.0
1 IN. C-45	13.4	14.3	13.9	13.0	14.6	-	-	13.8	.7
1 IN. C-47	12.1	12.2	12.9	12.4	14.2	13.8	-	12.9	.9
2 IN. C-47	11.7	12.2	12.2	12.7	13.0	12.8	-	12.4	.5
SHEEPSKIN	13.2	14.6	13.8	12.4	14.3	13.6	-	13.7	.8
	TIMES OF PEAK VALUE (msec)								
NONE	66	69	66	68	69	69	69	68	1
MIL-R-5001A	78	77	77	81	81	80	81	79	2
NACES	77	78	76	76	76	75	75	76	1
1 IN. C-45	80	80	80	80	79	-	-	80	0
1 IN. C-47	78	79	76	81	83	82	-	80	3
2 IN. C-47	77	85	81	84	83	84	-	82	3
SHEEPSKIN	77	80	78	76	81	81	-	79	2
	SEPERATION VELOCITY (FT/SEC)								
NONE	29.0	29.0	30.6	26.4	28.0	26.4	22.2	27.4	2.7
MIL-R-5001A	19.6	20.3	22.9	16.1	16.1	17.4	24.5	19.6	3.3
NACES	25.4	24.8	22.2	24.8	28.0	29.4	23.8	25.5	2.5
1 IN. C-45	25.8	26.4	27.1	26.1	25.1	-	-	26.1	.7
1 IN. C-47	29.6	26.4	30.9	27.4	24.8	25.4	-	27.4	2.4
2 IN. C-47	28.7	30.6	29.3	28.0	31.2	25.8	-	28.9	1.9
SHEEPSKIN	26.4	23.8	25.4	27.1	30.3	29.6	-	27.1	2.5

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

PELVIS FORWARD ACCELERATION

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (G)								
NONE	1.1	2.3	0.6	1.1	1.2	2.9	2.0	1.6	.8
MIL-R-5001A	1.3	1.3	1.6	3.6	3.4	4.6	1.2	2.4	1.4
NACES	3.8	4.0	3.3	2.6	2.7	2.7	2.8	3.1	.6
1 IN. C-45	3.1	2.1	2.4	2.2	2.0	-	-	2.4	.4
1 IN. C-47	1.4	2.6	3.5	2.8	1.9	2.1	-	2.4	.7
2 IN. C-47	3.9	3.9	3.2	3.4	3.0	2.5	-	3.2	.5
SHEEPSKIN	2.5	2.7	2.6	2.3	2.6	2.0	-	2.5	.3
	TIMES OF PEAK VALUE (msec)								
NONE	72	127	67	126	70	127	73	95	30
MIL-R-5001A	90	83	86	86	87	85	93	87	3
NACES	80	81	82	80	82	78	79	80	2
1 IN. C-45	127	126	92	84	86	-	-	103	22
1 IN. C-47	97	126	124	127	90	89	-	109	19
2 IN. C-47	126	125	124	127	127	126	-	126	1
SHEEPSKIN	92	94	87	127	126	92	-	103	18
	SEPERATION VELOCITY (FT/SEC)								
NONE	0.0	4.8	-1.9	-0.6	0.3	5.8	0.0	1.2	2.9
MIL-R-5001A	-3.9	-1.9	-2.3	0.3	-1.3	1.6	-4.2	-4.1	6.9
NACES	3.5	5.5	4.8	-0.3	4.2	2.9	3.9	3.5	1.9
1 IN. C-45	6.8	3.9	4.2	2.9	0.0	-	-	3.6	2.5
1 IN. C-47	1.6	4.8	8.1	5.5	2.3	1.9	-	4.0	2.6
2 IN. C-47	9.7	9.0	7.1	6.8	5.8	4.2	-	7.1	2.0
SHEEPSKIN	4.2	2.6	4.2	3.9	4.5	2.6	-	3.7	.9

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

THORAX FORWARD ACCELERATION

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (G)								
NONE	3.5	4.2	3.3	4.8	4.4	4.0	4.5	4.1	.5
MIL-R-5001A	7.0	7.3	7.0	5.5	5.4	5.8	4.9	6.1	1.0
NACES	3.8	4.4	5.2	4.6	4.6	4.8	4.9	4.6	.4
1 IN. C-45	5.4	5.1	5.0	5.3	5.6	–	–	5.3	.2
1 IN. C-47	3.0	4.8	4.3	5.3	5.5	5.8	–	4.8	1.0
2 IN. C-47	4.0	3.8	4.1	4.5	4.2	5.0	–	4.3	.4
SHEEPSKIN	4.5	5.3	5.1	5.1	5.1	5.1	–	5.0	.3
	TIMES OF PEAK VALUE (msec)								
NONE	137	139	125	133	137	127	124	132	6
MIL-R-5001A	137	134	127	124	131	168	136	137	15
NACES	125	126	123	124	122	124	123	124	1
1 IN. C-45	122	123	120	121	123	–	–	122	1
1 IN. C-47	122	123	122	124	123	122	–	123	1
2 IN. C-47	122	121	107	119	121	121	–	119	6
SHEEPSKIN	123	127	122	125	124	122	–	124	2
	SEPERATION VELOCITY (FT/SEC)								
NONE	8.1	8.7	8.1	10.3	9.3	8.4	10.3	9.0	1.0
MIL-R-5001A	13.5	13.9	12.6	13.2	12.9	12.9	9.3	12.6	1.5
NACES	7.7	8.1	8.7	9.0	7.7	8.7	8.4	8.3	.5
1 IN. C-45	8.4	8.4	7.7	8.1	9.0	–	–	8.3	.5
1 IN. C-47	5.8	7.7	6.1	7.7	8.4	8.4	–	7.4	1.1
2 IN. C-47	6.4	6.1	6.1	6.4	5.2	7.7	–	6.3	.8
SHEEPSKIN	7.4	8.7	7.1	8.1	7.4	6.8	–	7.6	.7

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

HEAD FORWARD ACCELERATION

CUSHION	1	2	3	4	5	6	7	AVG	STD DEV
	ORDER OF TESTS								
	PEAK VALUES (G)								
NONE	17.4	17.4	17.1	19.9	20.3	21.4	24.4	19.7	2.7
MIL-R-5001A	25.2	22.2	21.9	28.4	27.1	24.0	25.1	24.8	2.4
NACES	23.1	26.7	27.5	25.1	23.4	22.4	24.8	24.7	1.9
1 IN. C-45	24.9	25.6	23.6	23.5	26.9	-	-	24.9	1.4
1 IN. C-47	19.3	21.7	19.9	22.0	26.7	25.1	-	22.5	2.9
2 IN. C-47	20.2	20.1	20.4	21.2	19.6	23.8	-	20.9	1.5
SHEEPSKIN	24.1	26.2	24.9	20.7	22.3	22.9	-	23.5	2.0
	TIMES OF PEAK VALUE (msec)								
NONE	161	163	157	160	160	163	163	161	2
MIL-R-5001A	163	159	161	161	163	165	174	164	5
NACES	171	170	168	164	168	170	169	169	2
1 IN. C-45	160	162	169	171	169	-	-	166	5
1 IN. C-47	170	164	164	170	169	169	-	168	3
2 IN. C-47	172	169	168	171	173	171	-	171	2
SHEEPSKIN	170	172	170	162	170	172	-	169	4
	SEPERATION VELOCITY (FT/SEC)								
NONE	32.2	31.6	33.5	35.7	35.4	33.2	35.4	33.9	1.7
MIL-R-5001A	35.1	36.1	34.1	37.7	37.0	32.5	28.3	34.4	3.2
NACES	32.2	32.2	32.5	34.5	32.5	33.2	31.9	32.7	0.9
1 IN. C-45	34.5	35.1	31.9	31.6	30.9	-	-	32.8	1.9
1 IN. C-47	31.2	31.9	29.6	30.9	32.5	31.2	-	31.2	1.0
2 IN. C-47	29.6	31.6	31.6	31.2	28.0	31.9	-	30.7	1.5
SHEEPSKIN	30.9	30.9	31.2	32.8	30.3	29.0	-	30.9	1.2

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

LUMBAR COMPRESSION FORCE

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (LBS)								
NONE	1100	1108	1062	1065	1142	1207	1128	1116	50
MIL-R-5001A	1171	1152	1191	1474	1391	1375	1238	1285	127
NACES	1228	1316	1251	1186	1240	1121	1132	1211	69
1 IN. C-45	1148	1193	1129	1106	1160	-	-	1147	33
1 IN. C-47	1110	1093	1214	1181	1157	1120	-	1146	46
2 IN. C-47	1182	1212	1146	1145	1116	1121	-	1154	37
SHEEPSKIN	1150	1208	1168	1105	1164	1127	-	1154	36
	TIMES OF PEAK VALUE (msec)								
NONE	115	112	112	108	112	113	113	112	2
MIL-R-5001A	83	80	79	83	82	83	82	82	2
NACES	78	80	78	79	79	79	123	85	17
1 IN. C-45	123	122	122	123	122	-	-	122	1
1 IN. C-47	120	123	121	122	124	123	-	122	1
2 IN. C-47	125	116	118	123	123	124	-	122	4
SHEEPSKIN	122	84	124	124	124	124	-	117	16
	CURVE AREA (LB-SEC)								
NONE	114	118	113	111	116	123	115	116	4
MIL-R-5001A	104	104	104	111	108	106	106	106	3
NACES	115	119	118	114	119	114	117	117	2
1 IN. C-45	122	122	118	118	116	-	-	119	3
1 IN. C-47	118	117	124	121	119	116	-	119	3
2 IN. C-47	125	124	122	123	120	120	-	122	2
SHEEPSKIN	119	117	121	119	120	117	-	119	2

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

LUMBAR FORWARD SHEAR FORCE

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (LBS)								
NONE	238	171	248	266	257	186	293	237	44
MIL-R-5001A	357	345	336	368	376	274	326	340	34
NACES	222	231	245	299	216	248	261	246	28
1 IN. C-45	211	243	226	245	329	-	-	251	46
1 IN. C-47	206	200	138	194	276	276	-	215	53
2 IN. C-47	110	112	146	160	151	219	-	150	40
SHEEPSKIN	242	264	219	215	203	232	-	229	22
	TIMES OF PEAK VALUE (msec)								
NONE	122	154	121	153	157	167	167	149	19
MIL-R-5001A	167	166	165	166	168	131	169	162	14
NACES	168	168	167	164	167	169	169	167	2
1 IN. C-45	168	166	167	169	167	-	-	167	1
1 IN. C-47	164	169	162	168	168	168	-	167	3
2 IN. C-47	168	162	166	168	169	169	-	167	3
SHEEPSKIN	167	170	168	166	167	168	-	168	1
	CURVE AREA (LB-SEC)								
NONE	21.0	14.3	23.0	24.5	22.4	11.8	22.5	19.9	4.9
MIL-R-5001A	29.9	27.5	27.4	25.3	26.8	22.9	26.1	26.6	2.2
NACES	13.6	10.6	12.5	21.0	12.6	15.5	14.2	14.3	3.3
1 IN. C-45	9.8	14.3	12.1	14.6	20.2	-	-	14.2	3.9
1 IN. C-47	15.9	11.6	3.9	10.1	16.0	16.0	-	12.3	4.8
2 IN. C-47	1.9	2.3	6.6	7.1	6.9	11.8	-	6.1	3.7
SHEEPSKIN	13.6	15.6	11.7	14.8	10.9	13.9	-	13.4	1.8

STRIP CUSHION EVALUATION
EJECTION TOWER DATA
FIFTH PERCENTILE MANIKIN TESTS

LUMBAR FORWARD BENDING MOMMENT

CUSHION	ORDER OF TESTS 1	2	3	4	5	6	7	AVG	STD DEV
	PEAK VALUES (IN-LBS)								
NONE	971	695	1041	1106	1056	763	1216	978	187
MIL-R-5001A	1250	1110	1108	1348	1360	884	1228	1184	166
NACES	944	1007	1223	1186	927	998	1033	1045	115
1 IN. C-45	830	1025	908	965	1326	–	–	1011	190
1 IN. C-47	909	859	613	803	1158	1153	–	916	211
2 IN. C-47	566	612	734	764	709	970	–	726	141
SHEEPSKIN	977	1059	980	880	882	983	–	960	69
	TIMES OF PEAK VALUE (msec)								
NONE	123	157	122	156	157	167	161	112	2
MIL-R-5001A	167	168	167	167	169	128	170	82	2
NACES	168	169	168	166	167	169	169	85	17
1 IN. C-45	168	166	167	169	167	–	–	122	1
1 IN. C-47	160	168	166	168	168	168	–	122	1
2 IN. C-47	168	167	166	168	169	168	–	122	4
SHEEPSKIN	167	170	168	168	167	168	–	117	16
	CURVE AREA (LB-SEC)								
NONE	83	63	94	102	92	54	95	83	18
MIL-R-5001A	99	83	85	84	93	67	102	88	12
NACES	62	51	60	86	60	63	58	63	11
1 IN. C-45	43	68	53	60	83	–	–	61	15
1 IN. C-47	80	56	30	49	71	70	–	59	18
2 IN. C-47	30	33	49	48	46	62	–	45	12
SHEEPSKIN	62	68	61	67	57	66	–	64	4